(PUBLISHED QUARTERLY)

Journal of the Council for Scientific and Industrial Research.

Vol. I. FEBRUARY, 1928. No. 3.

The Policy and Aims of the Council for Scientific and Industrial Research.*

By A. C. D. Rivett, M.A., D.Sc., Deputy Chairman and Chief Executive Officer.

At the Perth meeting in August, 1926, Mr. G. A. Julius, Chairman of the Council, gave an outline of the position in which the Council found itself shortly after its creation. He pointed out the enormous value of the sympathetic constructive criticism which scientific men could give to the Council and expressed a hope that the Association would welcome an opportunity at each of its meetings to hear at first hand something of the plots and plans and maybe of the successes of the new Commonwealth organization. Scientific conferences nowadays are not for the announcement of great discoveries. They are for conferring and arranging for mutual aid and effective co-operation in the tasks of science.

Working with other Organizations.

In the interval since the Perth meeting abundant evidence has been furnished of the helpful goodwill of all bodies and individuals interested in the practical application of scientific knowledge and scientific method to the innumerable problems which face Australia. The Council gratefully acknowledges the sympathetic help it has received on every hand, but perhaps especially from the State scientific Departments and the Universities. I wish to lay emphasis upon this point, for if there is one thing that can strangle scientific effort in this Commonwealth, it is to be found in the misunderstandings that may arise, as in the past they have arisen, between different workers and groups of workers. The possibilities of such misunderstandings are ever present. What has been made plain to the Council for Scientific and Industrial Research during the past eighteen months is the existence everywhere of a willingness and a determination to find and remove the causes of such misunderstandings as soon as they show themselves. Nothing has been more encouraging to the Executive Committee during this time than the readiness with which such men as the Directors of Agriculture and their senior officers have drawn our attention to errors

* An address delivered to the Australasian Association for the Advancement of Science, Hobart, 16th January, 1928.

which we seemed likely to commit owing to insufficient acquaintance with existing circumstances. To discuss a grievance is, amongst scientific men, to remove it: to cover it up is to develop a sore.

Possibilities of Misunderstanding.

I do not wish to suggest that misunderstandings loom large in our little Australian scientific world, but it is perhaps because at this moment they do not that one may with the more certainty of avoiding them point out the possible dangers that are with us. One must candidly confess that the respective paths of Commonwealth and State organizations in the application of science to industry are not clearly defined. I see many a reason why the officers of a State might rather resent the entry of the Commonwealth into fields which they have tilled and in which they may feel they have the sole right to the honour and reward of the harvest. Nor does it take much imagination to understand that the entry of an organization with Commonwealth funds behind it may seem to many officers of State Departments to be a first step in reducing the importance of their own organizations. Anyone can see these and many other reasons for misgiving. But apart from the fact that such feelings may be based on an altogether too optimistic estimate of the powers of the Council for Scientific and Industrial Research, it remains a fact that after its year and a half of fairly crowded experience, the Council is convinced that if as the result of its coming into existence there is any diminution of State activities in scientific work, it will be a calamity of the first magnitude for Australia. There is not only room for both but there is an urgent need for both. The work of each should strengthen, and increase the need for, the other, and if at any time the respective paths are not clearly defined, continuous contact based upon candid, open and, it may be, very outspoken discussion will quickly show the way towards maximum effective co-operation. If the Council for Scientific and Industrial Research cannot create and maintain the desired spirit of comradeship amongst the various national organizations devoted to the advancement of Australia's material prosperity by the creation and application of scientific knowledge, it will have failed in one of its biggest tasks. There is room for all and, if I am not mistaken, the recent actions of the Governments of South Australia and Queensland show a fine determination to develop State scientific work in primary industries along lines which none will applaud more ardently than the Commonwealth Council for Scientific and Industrial Research.

The Example of the Agricultural Leaders.

Last March the State Agricultural Departments showed how willing and anxious they were to make a unity of agricultural research. I wish I could tell you the whole story of the two days' conference we had in Melbourne. Suffice it to say that a division of activity was decided upon which, on broad lines, assigned work of a fundamental type to the Council, while the States undertook to pay special attention to demonstration, extension and regulation. Up to the present the actual accomplishment of the Council on its side has not been considerable, but I believe that for many years the decisions of that conference will be of great significance in the progress of agricultural and stock investigations. At the moment they serve as an encouragement to those who are convinced that the will to co-operate is strong.

The Council's First Decision.

Let me now try to indicate briefly what the Council sees ahead of it. Last year Mr. Julius drew attention to our early determination to concentrate upon five main lines of work, viz., animal problems (including nutrition or "public health" as well as treatment of disease), plant problems, food preservation, forest products and fuel research.

You will see that for the present at least our chosen tasks are in primary and not secondary industries. I shall return to this point before long. Though the subjects named are few in number they are very broad in extent, and the Council is continuously fighting the temptation to expand its activities in all directions. The hardest task, it really seems, is to concentrate upon, and establish itself by success in, a relatively few major problems involving high financial stakes to industry. To succumb to the temptation to plunge into this, that and the other inquiry will be fatal in the end, though it may on occasion lead to partial success.

The Next Practical Step.

Having chosen its main lines of work, the next question was how best to grapple with them. Should we strive to work only through existing institutions, by direct monetary subsidization, by supplying assistants to workers already engaged on specific problems, by finding money for the salaries of junior teachers who would relieve senior Univeristy men of some of the routine duties which keep them from research work? Or should we found an independent organization altogether?

These questions have not been, and I begin to think cannot be, answered categorically. The adoption of any one of these means may at times be imperative for effective work. The Council must be free to vary its procedure according to circumstances and places. For example, it is at present convinced that in Western Australia successful work requires the adoption of methods not likely to be required in the East. Generally speaking, however, the Council is convinced that its main line of policy must be the establishment of its own laboratories, having the very best available men in charge of them, with strong supporting staffs. Only in this way can we strongly and effectively support other research bodies and profit most fully from their co-operation and assistance.

The Main Task: Selecting a Team of Leaders.

The main task of the past year, then, has been the search for a team of leaders, a group of six or eight men of the very first rank, to form the scientific spear-head of the Council for Scientific and Industrial Research. The Council is an important body, the State Committees and Executive are, let us hope, not without value, but in the end there is really only one thing that is absolutely essential, and that is capacity in the leaders and directors of research. They will make or mar Council and Executive and everyone else. If they succeed, there will be plenty of money for everything we want to do, and publicity will need no special officers. Nothing at present matters more to the Council for Scientific and Industrial Research than the selection of this team of leaders.

I wish we could tell you that the team has been selected and is at work. To me personally the rate of progress in this task is exasperatingly slow. I could never have conceived that it would take as long as it has to obtain a world-renowned entomologist to direct our activities against noxious insects and noxious weeds, or that by January, 1928, we should still be without a head for forest products work. It is some comfort perhaps to remember that the British Department of Scientific and Industrial Research took eight years to find the right director for its forest products laboratory. It is a time when everything urges towards quick work, yet the wise course is that of utmost caution and is inevitably slow in development.

It is unnecessary to set out in detail all that has been done in the past year and a half. Details belong to Annual Reports and to the modest quarterly *Journal* which we are publishing. Here one need indicate only how the main lines are developing.

I. Animal Nutrition Investigations.

First—animal problems. Throughout the Empire close attention is being directed to-day towards problems of animal nutrition. At the Imperial Agricultural Research Conference in London last October (where we were represented by Mr. Julius, Dr. Cameron, and Professor Richardson) an Imperial Bureau of Animal Nutrition was established at the Rowett Institute, Aberdeen. It is one of a number of bureaux. Just how they will function remains to be seen. Their claim to the term "Imperial" will depend upon their capacity to secure "Imperial" knowledge. This particular bureau is starting well. Its head, Dr. J. B. Orr, is coming to Australia in March to study at first hand our situation here. We are ready to welcome him with a growing organization under the direction of Professor Brailsford Robertson at Adelaide, the first man to be appointed to the team of which I have spoken. The establishment of the Animal Nutrition Laboratory is a fine example of co-operative effort between a University and the Council for Scientific and Industrial Research It is not my place to comment on University policy, but one cannot refrain from an expression of satisfaction at the attitude which the Council of the University of Adelaide has adopted in this connexion. By welcoming the establishment in its midst of a school devoted solely to research, it has indicated its conviction that in the education of students of medicine and of the biological sciences, contact with active research is no less important than instruction in text-book theory and hospital or laboratory routine technique. Results must not be expected for many years, but to thoughtful men, realizing the importance of the nutrition problem to Australia's industries of meat and wool production, the initiation of the work under Dr. Robertson must appeal strongly as a wise and far-seeing step.

II. Stock Diseases.

On the veterinary side of stock problems, the position is not so well defined, but we expect to have a strong organization in being before the end of this year. At present we are looking forward to the visit in March of Sir Arnold Theiler, the distinguished former head of the Veterinary Research Institute at Onderstepoort, South Africa, which he has made famous. He is to be the director of a new Imperial Bureau of Animal Health in Britain, and his visit to us will undoubtedly be of mutual advantage. Meanwhile we are doing what we can in

assisting leading investigators in Sydney, Glenfield, Melbourne, Adelaide, and Western Australia in their work upon a number of pressing problems. Though certainly not yet pulling our weight, we are doing all that is possible for some months to come.

III. A Department of Economic Entomology.

You will not need to be reminded that what is perhaps the principal step forward in the last few months has been taken in the development of an entomological section for the attack upon problems associated with both animals and plants. Before and since Dr. R. J. Tillyard was appointed to our staff, we received abundant evidence of the regard in which he is held by entomologists the world over. He is unquestionably amongst the foremost economic entomologists of the day. We are warned that he is far too optimistic and that his ideas and plans will overwhelm us by their magnitude. Well, he will unquestionably need all his splendid optimism, and we are ready to do all we can to help him on his overwhelming way, for indeed he has a colossal task ahead of him, and a chance to do more for Australia's material good in the next ten years than any other man who will join us. The central laboratories and insectaries will be at Canberra, where in fact all laboratories will be placed unless there is some special reason for putting them elsewhere. But particular problems will be investigated in sub-stations situated in the regions where these problems exist. Again I do not wish to go into details, but there is a general determination that first place in Dr. Tillyard's programme will be given to the task of eliminating sheep-blowfly by means of parasites. A special station will be established, probably in New South Wales, for the work, and the Council will do all that it reasonably can to staff it. I am not revealing any secrets, however, when I state that this staff will not satisfy Dr. Tillyard, and that we shall ask the pastoralists to join forces with us and through the fund which they are raising to-day, make it possible for the effort to be at least doubled in intensity. Might I say here that I hope that this meeting will not end without giving voice to the satisfaction of the A.A.A.S. at the splendid action of the pastoralists in initiating this fund.

Dr. Tillyard cannot take up all the problems that will be brought before him. He must select and reject. Buffalo fly, lucerne flea, and St. John's wort stand well up on the list. With Mr. Gerald Hill in the post of Chief Assistant, this entomology section, which I am personally inclined to regard as of more immediate importance than any other, has made a beginning which is full of promise.

IV. Plant Problems.

We have with us to-day, Dr. B. T. Dickson, formerly professor of plant pathology at McGill University, and I am sure that everyone present will extend a very hearty welcome to him. Like Dr. Tillyard, Dr. Dickson has felt the fascination of the almost limitless field which the Commonwealth presents to the economic scientist. At present he is touring Australia, meeting men and making notes, but before we meet again, I hope that he, too, will have been given the chances he can so well use for solving some of our most pressing mycological problems. His main station will be at Canberra, but while he is preparing his plans and supervising the erection of the first laboratories, we hope to secure for him the hospitality of our senior University, to whose Botany School our adviser on plant problems (Professor T. G. B. Osborn) has just been appointed.

V. Forest Products Work.

You will see how our team of leaders is growing. I cannot name to you yet the head of a forest products organization, but you know of Mr. A. J. Gibson's work this year in exploring the general position in Australia. We expect his report this month; and, while action cannot be taken in advance of it, I think it will not be deferred long after its receipt. Here again, it looks as if Canberra should be made the centre from which activities should radiate in all directions. You cannot wholly centralize research work of the type which is to be carried out; it would be folly to attempt it. But you can and must have a headquarters from which to develop the organizations which will spread here, there and elsewhere for specific purposes.

Headquarters are needed, too, for another purpose, namely, the training of the men of the future. I shall overcome the temptation to expand on this matter here in the hope that next year it may be more fitting and profitable to yield to the temptation. But I shall go so far as to say that the attention and thought of scientific men and women might well be directed in the coming months to the possibility of establishing in the Federal Capital Territory a post-graduate University which, on its scientific side, in active and intimate co-operation with the laboratories of the Council for Scientific and Industrial Research, will form a centre of attraction for graduates from all parts, and serve as a superb training ground for the leaders of the future. Only in some such way can we meet and overcome the present difficulty in obtaining men competent to face the tasks ahead, a difficulty which to-day is the greatest retarding factor not only in Australian but in Imperial scientific and industrial research. One might suggest, too, that here is a way in which we can help our colleagues directing the State Departments, by providing a reservoir of first-class trained investigators upon which they also can draw.

VI. Dairy Research.

Dairy research has presented rather an interesting problem to the Council during the past year. As you know, all the States are very active in this direction, and the heads of the several Agricultural Departments have put forward sound reasons for their view that there is at present no special place for the Commonwealth to fill. The Australian Dairy Council holds a different view. After looking carefully at every point of view the C.S.I.R. proposes to put the matter to the test. Professor Richardson is drawing up plans for the establishment of a modest laboratory to be staffed by the best chemist, bacteriologist, and pathologist that we can obtain. If the need exists, this laboratory will develop apace; if it does not, we shall have lost little. Certainly this is not a case for plunging into a grandiose scheme of National Research, written in large capitals. Here almost more than in any other line, the future depends upon the way in which States and Commonwealth work together. It has been most puzzling, yet not without great interest, to find how heartily dairy experts can disagree with one another. Musicians may perhaps beat them, but possibly not by much.

VII. Food Preservation.

Food (including meat, fish, and fruit) preservation in store and during transport will always be to the fore amongst questions confronting people in a country of huge internal distances and separated by

thousands of miles from the main markets of the world. Dr. and Mrs. Kidd have brought their English experience to bear upon our problems during the past few months, and their advice has been very helpful. The Council is proceeding cautiously. I cannot announce the initiation of big plans for laboratories and cool stores and experimental shipments and the many other expensive schemes towards which we are urged by enthusiastic folk, who think in tens of thousands of other people's money more readily than the Council has yet learned to do. On the laboratory side we are starting work steadily. On what may be called the field side, the big need is knowledge of what has already been done elsewhere. Where science and commerce are inextricably interwoven, it is not always easy to get facts of others' experience, but it is wise policy to seek these facts rather than to endeavour to obtain them *ab initio*. Take one example. We were urged last season to recommend the Commonwealth Government to guarantee at least 20s. (later 25s. was sought) a case on a trial shipment of 10,000 cases of oranges, these to be picked under inevitably varying conditions from various States and districts and put into holds not designed in accordance with best modern engineering knowledge. We were then to see what happened as regards temperature changes and so forth throughout the voyage. The Council was convinced that the policy was unsound and declined to act on the lines proposed. South Africa and California are far ahead of us in citrus transport, and they are willing to teach us. To start *de novo* would be folly. We are at present engaged in compiling a statement setting out details of proved successful practice in these countries, and this will be made the starting point for our own investigations of this particular matter. Meantime, orange drinks at 4d. each are providing an exceedingly practical answer to the question of how to dispose of Australia's citrus harvest.

For the present I would rather not say much by way of prophecy, but the work of the States, the work of the British Department of Scientific and Industrial Research and the experiences of other Dominions and foreign countries, if properly assimilated and applied, give openings for most effective work in food preservation which I hope we shall not be slow to seize.

VIII. Fuel Research.

One word about fuel research, possibly the most expensive single line of national research in vogue to-day. There is, as everyone knows, immense activity in this direction on the Continent and in Britain. We are in the happy position of being assured of the results of this work without sharing in the costly search for them. I know full well the capacity of some of us to jibe at the idea of Australia sitting back and relying upon the work of others. Here is an opening for them, but I advise them not to take it. The more one studies the matter the more convinced does one become that it would be the sheerest folly for the Council for Scientific and Industrial Research to plunge into modern fuel research on an adequate scale at present. Our time will come. Meantime we have men in training in England, in close touch with every development as it occurs.

The Special Case of Shale.

This being Tasmania, perhaps I may be permitted to mention shale. The attitude of the Council towards the shale problem may not be approved by many of you; but at least it is definite and intelligible.

If the Council had unlimited funds shale would offer an attractive field for research. It has not. Therefore it must choose those lines of work which offer the greatest prospect of economic return to the Commonwealth. The shale industry is to-day not economically profitable. To make it so by scientific research work may be possible; let us not destroy any one's simple faith about research. But the cost would be immense—far beyond the total resources of the Council. Even if attained, success would mean little compared with success in the numerous other fields in which we are engaged. Therefore the Council will not, for the present, touch the problems that gather round that rather fascinating material "shale."

Other Activities.

(*a*) *Irrigation.*

Now that the various divisions of our five main lines of work have been spoken of, let me very quickly pass in review some more or less unrelated activities.

The work of the viticultural and citrus stations at Merbein and Griffith respectively is being continued. The wisdom of effecting something of a revolution in the viticultural work has become evident to the Council and a project to establish a new station, planned on more modern lines, at Coomealla had advanced some distance when the possibility arose of establishing an Imperial Irrigation Station in Australia with the help of the Empire Marketing Board. We formulated a general proposal, thinking it to be original, only to find that already the idea of an Imperial Station had received quite a great deal of attention in Britain and that Palestine, Sudan, and India were already in the field as candidates with high claims. The position to-day is that a technical sub-committee of the Imperial Economic Committee is meeting this month in London to go fully into the whole matter. We cannot hope for its report until June. What our chances are no one can say. We know that Australia's claims will be well put by Mr. F. L. McDougall, our liaison officer in Britain. The prospect seems, however, to be sufficiently good to justify us in holding our hands for the present at Coomealla, which may not be the best site for the greater scheme. If we get the Imperial station, the event will prove our present wisdom. If we do not, we shall bemoan our folly in losing six months of activity on our own relatively minor project.

(*b*) *Tropical Research.*

In Queensland the Empire Marketing Board scheme for a Tropical Agricultural Research Institute has provided much food for thought. This is not the place for full discussion of the matter, but it may be advisable to indicate that the soundness of the idea of establishing a single, more or less self-contained, Institute in one spot in Queensland is being questioned. Rather does it seem wise to allow our tropical activities to radiate from the group of leaders I mentioned earlier, and sub-stations (not necessarily either large or permanent) to be established wherever a specific probelm may best be attacked, whether in Queensland, Northern Territory, Papua, or New Guinea. But of that—more next year.

(*c*) *The Proffered Sheep Station in Queensland.*

While talking of the North, appreciative mention might be made of the generous offer of the Government of Queensland to give the Council for Scientific and Industrial Research a 30-years' lease, free

of rent, of 25,000 acres at Saltern Creek in the Barcaldine district to be used for revenue-producing purposes and for investigation into problems of the sheep industry.

The decision not to accept this offer was not easily made, even after its wisdom was apparent, since the promptings of normal human nature were of course towards grateful acceptance. All I want to do here is to ask any one who is disappointed at the Council's decision to look very carefully into the facts, which are readily available. No doubt the Queensland Government is disappointed at our action; in the end, or long before the end, I believe it will agree that we have done the right thing.

(*d*) *Geophysical Prospecting: Tobacco Growing.*

I have not mentioned the coming big test of geophysical prospecting methods, nor the attempt to get the answer to the question of how to grow in Australia tobacco that Australians will buy and will smoke. With the Development and Migration Commission we are entering into both subjects with all the vigour we can supply.

What About Secondary Industries?

So far all this talk has been about primary industries. Is the Council prepared to define its attitude towards secondary industries? It is, on condition that it is not asked to define strictly either of the terms "primary" and "secondary."

Speaking generally, the scientific problems of secondary industries are great in number, but relatively restricted in incidence. No farmer or group of farmers can clear Queensland of prickly pear, or Victoria of St. John's wort. These are matters requiring action by the people as a whole, and in Australia that means by Governments. But there is very strong ground for believing that Government organizations are not the right agencies for attack upon the specific problems of the manufacturer. The individual firm or company can solve most of them, if it has the will; the industry as a whole, if banded together, can more profitably attack others as is being done in Britain to-day with such signal success. There will remain a few where the problem is a very broad and fundamental one and beyond even an industry; and here a Government may profitably come to the aid of, say, an Industrial Research Association if the latter can demonstrate its need for such aid.

The Council will not take up the individual problems of this firm or that. Well-managed, intelligently-directed companies will never ask it to do so; they can do the job better themselves, and they know it. We come in, if at all, only on bigger issues, where all thought of secrecy, individual processes, patents, and so forth vanishes. Thus in radio work we have a part to play which no manufacturers of wireless outfits can play—and our Radio Research Board is doing it. No engineering firms can keep and maintain ultimate standards of length, mass, voltage, and resistance with an accuracy 100 times greater than the practical needs of their shops demand. Yet this must be done. That is our job, in co-operation with the Defence Department and the Universities, and we are doing it through our Maintenance of Standards Committee.

But into the details of secondary industrial development, the Council for Scientific and Industrial Research as such will be ill-advised to enter.

The General Outlook and the Successes of the Year.

Is Australia prepared to employ the methods and results that members of an Association like this can offer it? I believe it is—at any rate vastly more so than it was twenty, or even ten, years ago. But even if one is wrong in that, do you not think that the position in the world to-day is such that we may feel absolutely confident that we shall be given in the immediate future opportunities to prove our worth to the full? No longer need Science hawk her wares and make fulsome promises in the hope of attracting the notice of condescending patrons. The attitude of the suppliant, not of the patron, is in evidence to-day, in British communities no less than in others, and the testing time is with us. By their fruits ye shall know them; and I want to end this general statement with what to-day can be only a paragraph, but which in years to come will, let us hope, be the burden of this address, namely, a statement of the successes of the Council for Scientific and Industrial Research since our last meeting.

(i) The glass house erected in the grounds of the Waite Institute for the investigation of virus diseases of plants is in full working order and the insect vector of tomato wilt, the first problem tackled, has been discovered.

(ii) There is good reason to suppose that the cause of Kimberley horse disease has been found. No definite announcement can be made, however, for at least two months. This mention of it is quite unofficial.

(iii) Most valuable work on mechanical pulp and the production of newsprint has been completed and made public. Tasmania has much to gain from this work and from that which preceded it.

(iv) In co-operation with the Development and Migration Commission and with the active assistance of Messrs. Australian Paper Manufacturers Ltd., a most satisfactory demonstration has been made of the value of *Pinus insignis* pulp for the production of high-class kraft wrapping papers. The recent development of pine forests makes this work of special interest and economic importance.

(v) We have shown the way towards parasitic control of ragwort, a slight plant pest in Australia, but one causing much anxiety in New Zealand.

(vi) The work of the Commonwealth Prickly Pear Board in developing the biological control of pear is giving abundant ground for quiet satisfaction. At the same time it is not possible to ignore dangers from hyper-parasites both of the cochineal insects and of cactoblastis. A marked speeding up of the work has been determined upon. In all this the Council for Scientific and Industrial Research gratefully records its appreciation of the hearty co-operation between the Governments of the Commonwealth, New South Wales and Queensland which has made possible the work of the Board, and not less heartily acknowledges the magnificent work which is being done both independently and in association with the Board by the Queensland Prickly Pear Commission. Many agencies share in the honour of this work, and the Council is fully alive to the fact. At the moment success seems in sight for what has been described as the greatest (in the sense of being on the biggest scale) experiment in economic entomology which has ever been made.

The Production of Bright Flue-cured Tobacco in America.

By G. P. Darnell-Smith, D.Sc., F.I.C., Director of the Botanic Gardens, Sydney.

1. General.
2. History of Tobacco Production in U.S.A.
3. Economic Considerations.
4. Large and Small Tobacco Farms.
5. Tobacco Standards proposed by U.S.A. Department of Agriculture.
6. Tobacco Growing Soils of North Carolina.
7. Varieties suitable for Bright Flue-cured Tobacco.
8. Fertilizers.

1. General.

On behalf of the Tobacco Investigation Committee* I visited America during the months of August and September to survey the flue-cured tobacco industry. This industry has in recent years shown an enormous expansion owing to the great number of cigarettes now smoked both by men and women. Unfortunately, the tobacco hitherto produced in Australia has not possessed that pleasant aroma that appeals to the smoker, nor has it been of the type demanded by the consumer in Australia. Until, therefore, the aroma, quality, and type can be improved, it does not appear likely that the demand for it will be great, and large quantities of American tobacco will have to continue to be imported.

As the tobacco plant is peculiarly susceptible to changes in soil and climate, the conditions under which the desirable types are grown in America become of great interest to the prospective tobacco grower in Australia, and close observations were made accordingly into the physical and chemical constitution of the soils in which bright flue-cured tobacco was grown, and the prevailing climatic environment.

The land used for growing bright flue-cured tobacco in the United States now covers an area of approximately three-quarters of a million acres and produces, in round numbers, a little more than half a billion pounds, or more than one-third of the total tobacco production of the country.

Flue-cured tobacco is grown in the southern part of Virginia, in the north-central and eastern sections of North Carolina, in southern Georgia, and in northern Florida. Throughout my travels in these districts I was received with the utmost courtesy, and facilities were placed at my disposal to get the greatest benefit from my visit. In particular I am indebted to Mr. E. G. Moss, Director of the Tobacco Experiment Station, North Carolina, and to Mr. E. Floyd, tobacco specialist for the State of North Carolina, who helped to arrange my itinerary and often accompanied me.

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* This Committee has been appointed to control the tobacco investigations being carried out by the British-Australasian Tobacco Co. Ltd., the Development and Migration Commission, and the Council for Scientific and Industrial Research, working in co-operation (see this Journal, Vol. I., No. 1, page 16). Dr. Darnell-Smith's visit to America was arranged by kind permission of the New South Wales Department of Agriculture.—Ed.

2. History of Tobacco Production in the United States of America.

The history of tobacco production in the United States has not been one of simple expansion, but rather there has been throughout a tendency towards increased specialization. The early settlers in Virginia produced at first but a single fundamental type of tobacco. As its culture was carried from the first settlement at Jamestown into new territory, it was seen that the changes in soil and climate resulted in important differences in the character of the tobacco produced. It was learned that desirable characteristics of the tobacco leaf resulting from local soil and climatic influences could be further accentuated by modifying the methods of growing and curing. Thus, through a process of gradual evolution, tobacco culture has become highly specialized, each producing district furnishing a distinctive type of leaf especially adapted for certain uses, based ultimately upon the tastes and preferences of the consumer. It is the accumulated experience of three centuries of tobacco culture that each of these types can be produced only under certain conditions of soil and climate, by using certain varieties of seed, and by employing special methods of growing and handling the crop.

With the advent of flue-curing and the demand for a bright, aromatic leaf for cigarettes now so universally smoked, more and more tobacco has been grown upon the light sandy soil of Virginia, North Carolina, South Carolina and Georgia, and less and less upon the heavy soils. Such heavy tobacco as is produced is sold mostly to European countries. Thus the tobacco of Maryland, which was originally exported to France by Lord Baltimore because he had freedom as regards his exported leaf, is still exported to that country. The fire-cured leaf of Virginia is exported principally to Austria and Italy. Some tobacco of this type is also smoked by the French-Canadians. Neither of these types would have any sale in Australia.

As regards cigar leaf, the consumption of cigars, in spite of the increased population, has remained almost stationary, and it is not probable that it would pay to consider the production of cigar leaf in Australia at present. Cheap cigars, sold at from 5 cents to 10 cents each at one time, had a great vogue in the States, but the sale of these is diminishing, while the sale of cigarettes is rapidly increasing. The large tobacco firms are all concentrating on the production of cigarettes in packets, which are sold under distinctive labels, "Lucky Strike," "Camel," "Old Gold," &c. The same phase is exhibited in Australia, where the demand is for "Capstan" and "Three Castles" cigarettes. In Australia the tobacco must be of a bright colour; in the States the demand by the public for a very bright coloured tobacco in cigarettes is not so insistent, though it must be bright, and it is almost invariably mixed with a small amount of Turkish tobacco, which is imported. In America locally grown leaf is known as domestic tobacco, while outside the States tobacco grown anywhere in America is known as Virginian, although not a great amount of tobacco, comparatively, is now grown in that State.

3. Economic Considerations.

The two "money" crops in the Carolinas are tobacco and cotton. To be profitable, tobacco should average not less than 25 cents. a pound; cotton should average not less than 20 cents a pound. Last year

cotton went as low as 12 cents a pound, with the result that a much larger acreage was put under tobacco. This year the season was good and there was a larger tobacco crop than usual; as a result prices were somewhat low. The average in most of the markets that I attended was about 20 cents.

There is a great tendency for farmers to devote all their attention to these two "money" crops. Sometimes they specialize in one only. The agricultural authorities do not encourage this method of farming. They consider that it is better for a farmer to devote his attention to several crops, such as corn, soy beans, tobacco and cotton, and to keep some animals. They do not encourage him to specialize except, if one may use the paradoxical expression, to specialize in diversity, i.e., to grow divers crops, but to see that he grows the best of each. It is considered that by adopting this method he minimizes his risk of loss by spreading it, and is more easily able to manage his labour. Most of the labour is done by negroes and negresses, the wages being, negroes $2.50 per day, and negresses $1.50 per day. Often, however, the farmer's family assist, and it is thought that more diversified labour keeps them more contented. There is another aspect to the question. Where a farmer devotes himself to raising tobacco and tobacco only, his quest of wealth may lead him to neglect to keep a cow or to raise vegetables. His children do not look healthy, and have putty-coloured faces; this I attribute to an insufficient variety in their diet. Where the soil is sandy, but fairly rich, as in the so-called savannah region, it pays better to grow truck crops than tobacco. The interesting point is that here tobacco crops can be and are raised within a few miles of the sea.

Formerly there were a number of tobacco markets, even the small towns usually having one. With the advent of the motor car and the construction of concrete roads, it has become comparatively easy for a farmer to carry a load of tobacco 50 miles or more for sale. If he is not satisfied with the price obtained for one load at one market he takes the next load to another market. There are likely to be more buyers in the big markets, and with transport difficulties overcome, there is a tendency for the smaller markets to be closed from want of adequate supplies, and the large markets to become bigger still.

4. Large and Small Tobacco Farms.

There are comparatively few large tobacco farms. Most farmers own small farms, from 50 to 150 acres, upon which they raise a variety of crops, the chief being maize, cotton and soy beans, cow-peas and tobacco. The area under tobacco is usually from 4 to 10 acres.

There are, however, a few farms with a much greater acreage under tobacco. The largest is the "Never Fail" tobacco farm in the Piedmont district of North Carolina. This farm of 1,350 acres is held by a syndicate and has 175 acres in tobacco. There are 47 tobacco curing barns and 40 men with their families working on the place. The farm is managed by a Mr. Blackwell, with whom, and Mr. Floyd, a tobacco specialist, I went over the farm on 18th August. At this time much of the crop was in, much was being cured in the barns, and some was still in the fields. All the tobacco will be sold by the end of November. The families work upon half shares. There are two immense pack houses of galvanized iron; all the barns are

made of wooden logs, the crevices being filled with mortar and sand. This is the type seen almost universally throughout the flue-cured tobacco belts. In the packing houses the tobacco is placed, as cured, still on the sticks, in "windrows." When time permits these are placed in "coops" or "books," i.e., they are packed in squares, eight sticks to a layer, and the layers are piled one upon the top of the other, about 8 feet high. They are then left in the packing house until the time comes for making hands. When this arrives a quantity of the tobacco is placed in a "pit," a large open space or room with an earthen floor at the base of the packing house, for one night. Here it will "come into case," i.e., it will pick up sufficient moisture to be easily handled next day without breaking. (A little steam is blown into the pit if the air is too dry.) Large doors open from this pit to the grading and handling floor, a large room, where eight to ten people work at grading and making hands with full light from windows.

All the tobacco grown at this farm is of the White-stem Orinoco variety. The variety known as "Cash" has been tried, but is thought to be sometimes somewhat short in the leaf, though it is rather more elastic than White-stem Orinoco. Two furnaces to the barn, instead of one, are preferred at this farm.

The manure used was 8.4.6* at the rate of 1,000 pounds per acre, with 200 pounds per acre of a mixture of one bag of sodium nitrate to two bags of the above general fertilizer applied as a side dressing just before the flowering time. The side dressing is put at the sides of the hills, the main dressing is put in the centre of the hills just before planting. The potash is generally derived from half muriate and half sulphate of potash; the nitrogen is generally derived from one-third cotton seed meal, one-third nitrate of soda and one-third fish scrap.

At one spot on this farm Granville Wilt has made its appearance. No remedy for this is known, but rotation of crops is recommended. Here the rotation maize, cow-peas, oats, tobacco, is practised. Cow-peas and Japanese millet are grown together at this farm for fodder, and are cut just when the cow-peas start to harden. Mules are used entirely for traction and cultivation.

5. Tobacco Standards proposed by the United States Department of Agriculture.

The result of the farmers' co-operative movement was to show that tobacco leaf could be fairly accurately classified. The United States Department of Agriculture has been giving considerable attention to the matter and has proposed, as a classification, a system which goes much further than that adopted by the co-operative farmers.

It is proposed to take each class of tobacco, bright flue-cured, burley, fire-cured, &c., and to deal with them separately. I shall deal briefly with the suggestions made in regard to bright flue-cured leaf only. This will be divided into four types, according to where it is grown:—

Type 1.—North Carolina—Old belt.
Type 2. North Carolina—New belt.
Type 3. South Carolina.
Type 4. Georgia.

* These figures indicating the percentages of phosphoric oxide, ammonia, and potassium oxide, respectively.

Each type will then be graded into groups; each group will then be graded into qualities, and each quality will be graded into colours.

The group signifies mainly the purposes to which the leaf is to be put in the course of manufacture. The quality embraces a great variety of characters and is the most difficult part of a tobacco leaf to judge. Characters upon which quality depends are cleanness, soundness, smoothness, texture, elasticity, amount of oil, amount of wax, maturity, grain, solidity, body, strength, colour shade, venation, width of leaf, length of leaf, shape of tip, cure, uniformity and injury. The colour is the colour of the leaves in a hand after curing and grading.

There are four types and six groups in each type, nine qualities in each group, and five colours in each quality. There are, therefore, in each type, 270 grades, into any one of which a hand might be put.

The groups and the grades are as follows:—

Groups.

A. Wrappers.
B. Heavy leaf or cutting leaf.
C. Thin leaf or cutters.
X. Stemming lugs.
Y. Granulating lugs.
F. Priming lugs.

Qualities.

1. First quality.
2. Second quality.
3. Third quality.
4. Fourth quality.
5. Fifth quality.
6. Sixth quality.
7. Seventh quality.
8. Eighth quality.
9. Damaged quality.

Colours.

L. Lemon.
O. Orange.
R. Red or mahogany.
D. Dark red or walnut.
G. Green or greenish cast.

Under the head of quality a schedule has been drawn up showing the particular qualities that a leaf must possess to come under No. 1, No. 2, No. 3, &c. (It is not included here for the sake of brevity.) If the scheme were adopted, then when tobacco had been graded according to it, the grade and quality of a tobacco could be indicated by attaching to it a label with the distinctive letters and numbers shown in the foregoing tables, and if one were familiar with the scheme, all that is required to be known about a basket of tobacco could be ascertained by looking at the label.

The following examples will serve to illustrate the method of classification which has been outlined above:—

Grade A4O.—Good quality wrapper in orange colour. Elastic, clear finish, smooth, oily, ripe, clean, sound, uniform in colour, small and blending fibres. Not more than 2% of injury.

Grade C3L.—High quality thin leaf in lemon colour. Clean, sound, thoroughly ripe, smooth, clear finish, uniform in quality and colour, blending fibres, containing no coarse leaves. Not more than 10% of injury.

6. Tobacco Growing Soils of North Carolina.

The State of North Carolina is by far the most important State in the production of bright flue-cured tobacco. This year, out of a total of 625 million pounds, it will produce 400 million pounds.

Special attention was given to the soils of North Carolina, as the nature of the soil upon which tobacco is grown appears to be, by far, the most important factor in determining the colour, texture and aroma. The State, so far as tobacco production is concerned, can be divided roughly into three divisions of about equal area.

(*a*) The western or mountainous section. Comparatively little tobacco is produced here, and what is produced is nearly all of the Burley type. For the purpose of the present discussion, this section can be dismissed.

(*b*) The medium section is known as the Piedmont section or old tobacco belt. The soil here is derived mostly from granite or similar rocks, though some is derived from sandstone and slate. This section produces the finest tobacco.

(*c*) The eastern section is known as the coastal plain or new tobacco belt. The soil here is mostly of marine origin, and even the small pebbles are water worn and smooth. Some fine tobacco is produced in this belt, but, as a rule, it has not as much body as that produced in the Piedmont section. Owing to the greater humidity, tobacco cannot be kept long after harvesting, and firms do not erect store-houses for tobacco in this section.

A soil survey of this State has been made, and I am indebted to the Department of Agronomy of the State College of Raleigh for much information concerning the soils of North Carolina.

Soils of the Coastal Plain.—The soils of the coastal plain are derived mainly from unconsolidated sands, silts and clays of marine or sedimentary veins. In places this material has been modified by wind action, and in other places it has been covered by a layer of commulose material as vegetable matter varying in thickness from a few inches to many feet and being mixed with the soil material to varying depths. The coastal plain may be divided into three main areas—sand hills, the middle coastal plain, and the flatwoods.

Piedmont Soils.—The Piedmont soils are residual soils which have resulted from the weathering of the underlying rocks. They owe their characteristics to differences in the character of the parent rock, to differences in the degree of weathering to which the rocks have been subjected, and to differences in topographic position. On the basis of the character of the underlying rocks, the Piedmont province has been divided into three sub-provinces—the Crystalline Rock division, in which the rocks are mainly granites and acid gneiss and schist, with smaller areas of basic igneous and metamorphic rocks; the Carolina State belt, consisting mainly of fine grained acid volcanic rocks which have been altered to slates, but with smaller areas of basic volcanic rocks; and the Triassic Sandstone and Shale division, where the rocks are largely grey to purplish red sandstones and shales.

Generally, the more sandy the surface soil, the more sandy the sub-soil, the less the humus, the less the clay and the greater the aeration, the better the soil for growing tobacco that will produce bright flue-cured leaf of good flavour and aroma, always provided that a suitable fertilizer is applied and an adequate rainfall occurs throughout the growing period.

An analysis of the physical characters of some of the American soils referred to is given in the following table, and for comparison are given also two analyses from the "light" and "heavy" soil upon a tobacco farm at Tamworth, New South Wales.

PHYSICAL CHARACTERS OF TOBACCO-GROWING SOILS IN NORTH CAROLINA AND NEW SOUTH WALES.

——	Fine Gravel.	Coarse Sand.	Fine Sand.	Silt.	Clay.
AMERICAN SOILS.					
North Carolina—					
Cecil sandy loam	5·3	26·9	35·4	23·6	8·5
Durham sandy loam	6·3	40·8	31·4	17·9	3·8
Durham coarse sandy loam ..	12·9	20·5	31·4	19·4	5·8
Granville coarse sandy loam ..	15·3	34·3	22·6	19·2	8·0
Norfolk coarse sandy loam ..	·0	·8	70·0	19·0	10·3
Georgia—					
Tifton sandy loam	0·8	15·8	62·8	12·0	8·2
AUSTRALIAN SOILS.				Silt and Clay.	
Tamworth light	0·09	..	13·47	86·44	
Tamworth heavy	0·08	..	4·75	95·17	

It will be seen that in the tobacco soils of North Carolina and Georgia, used for growing light flue-cured tobacco, the sand and gravel generally total well over 70 per cent. Chemically, these soils are poor.

The available phosphoric acid varies from .0005 to .009, and the available potash from .007 to .0108. The deficiency is made up by the supply of suitable fertilizers. These sandy soils are comparatively easy to till and to keep free from weeds. The tobacco plant forms in them a great amount of healthy white root fibres. While in the method of ridge cultivation care is taken not to disturb the basal roots of the plant, soil is heaped up around the stem and wherever this is covered with soil it sends out fresh feeding roots.

As the soil becomes richer by better farming methods, closer planting and higher topping are practised. A good leaf cover over the soil is desirable. It is held that there is less danger to tobacco leaves from the direct rays of the sun than from heat emanating from the soil. However ideal the mechanical and chemical qualifications of a soil for tobacco growing may be, good drainage is essential.

Plants with large stems and large leaves are not regarded as suitable for flue-curing. A good yield is 800 pounds per acre.

Tobacco is usually planted out in the fields from the seed-beds about the 15th of May. It is harvested towards the end of August. A reference to weather charts kept in the neighbourhood of the Oxford Tobacco Experiment Station indicates that during the important growing period of June, July and August the temperature is never less than 55*, and the relative humidity never less than 52°. Usually they were much greater. The mean temperature was 78.7°. The rainfall was evenly distributed, and there was very little wind. For example, in 1925, the rainfall was in May 4.71, June 2.60, July 1.98, August

3.42, September 4.36. In June, July and August, there were seven days in each month when the precipitation was 0.04 inches or over, the number of cloudy days was 61 out of 92, and the average hourly velocity of the wind was 7.3. On 43 days the temperature was 90° or over. The ideal climatic conditions are evidently a calm atmosphere, a high temperature, great humidity, cloudy days and a moderate, but evenly distributed, rainfall.

7. Varieties Suitable for Bright Flue-cured Tobacco.

The origin of these varieties it is not possible to trace. Sometimes a sport or variation is noted by a man and is continuously selected by him, eventually receiving his name if the variety becomes popular. I met one farmer who had adopted the practice of selecting his own seed for 30 years, and another who had done so for 18 years. The varieties they are using may eventually become known by their names.

The difficulty of tracing the origin of a variety is increased by the fact that often one variety is known by one name in one part of the country and by another name in another part of the country. A good variety is one which has vigour and a long and fairly broad leaf on which the midrib and veins are not too prominent. It should mature early and evenly and cure evenly in the barn with a bright lemon or orange colour and a sweet aroma. Its texture, when cured, should be smooth, tough and elastic. It should have body enough to give weight.

Varieties having the foregoing qualities and which are grown very generally throughout the Carolinas are:—Cash, Hickory Prior, Warne, and White Stem Orinoco. It may be possible that the best varieties grown in the Carolinas will not prove to be the best in Australia. Other varieties which are worthy of trial are:—Gold Leaf, Adcock, Hester, Narrow-leaf Orinoco (Wildfire resistant), Little Orinoco, Jamaica, Flanagan.

8. Fertilizers.

The necessity for applying suitable artificial fertilizers to the various classes of soils enumerated has been recognized, and has been the subject of prolonged research and very extensive experiment at the Oxford Tobacco Station, under the supervision of the Director, Mr. E. G. Moss. The elements to which special attention has been given are phosphorus, nitrogen, potash, magnesium and calcium.

(*a*) *Phosphorus.*—This element is almost invariably supplied in the form of superphosphate. For the making of this large supplies of phosphatic rock are available in Tennessee.

In speaking of any mixture of artificial fertilizers, it is usual to speak of the phosphorus, nitrogen and potash which they contain, meaning thereby the amount of phosphoric oxide (P_2O_5), ammonia (NH_3), and potassium oxide (K_2O) which they contain. As they always are mentioned in the order given above, by an 8.3.4 mixture is understood one which contains 8% of P_2O_5, 3% of NH_3, and 4% of K_2O.

Experiments and observations repeated over a number of years have placed the operators in a position to diagnose very largely the wants of a tobacco plant by examining the foliage. The need of

additional superphosphate is indicated by the failure of the plant to mature early. Superphosphate undoubtedly stimulates early root development, but it has also a profound action upon the metabolism of the plant, and the lack of an adequate supply of superphosphate results in the leaves of the plant remaining green for a long time and failing to show the yellowish blotches and general yellow cast that is indicative of maturity. Any sample of superphosphate has with it, necessarily, a large amount of calcium sulphate, which probably has some action upon plant metabolism. The exact role of the action has not been determined, and for the purpose of tobacco production it suffices to know the amount of phosphoric acid to apply, irrespective of the amount of calcium sulphate which may accompany it. The superphosphates used in America contains 16% of soluble phosphoric acid. A few years ago the general manure for tobacco crops recommended to farmers was an 8.3.3 mixture. Further work has shown that, generally, a 10.4.6 mixture can more profitably be employed, i.e., the percentages of phosphoric acid, ammonia and potash have all been increased.

It has been found that, while on sandy soil, this is the highest amount of superphosphate that can be applied with safety (at the rate of 800 pounds to the acre) a great deal higher percentage can be applied upon soil containing a fair percentage of clay. It is possible, that on sandy soils much of the soluble portion of the superphosphate at once goes into solution when it rains, and if a too concentrated solution were produced exosmosis would take place from the root hairs.

In clay soils much of the phosphoric acid may enter into a state of loose chemical combination in the soil, and exosmosis, in consequence, may not take place. As the tendency of tobacco growing upon soils containing much clay is to be late in maturity, and as phosphoric acid hastens maturity, and plants growing in clay soils can stand a large application of it, the recommendation is to increase the amount of phosphoric oxide in the fertilizer applied from 10 up to as much as 18 per cent.

A new product, ammonium phosphate, has been tried at the Oxford Experiment Station, but the experiments are not yet sufficiently advanced to make definite recommendations in regard to its use.

(*b*) *Nitrogen.*—While nitrogen is a necessary constituent of plant food, the soils of North Carolina are very deficient in it. It has been determined that too much nitrogen is objectionable in tobacco growing, producing plants of a rank, coarse growth. Again, if too much nitrogen is applied in the form of fertilizer to the soil the plant cannot assimilate all that it takes up, and the leaves become covered with brownish blotches, which may become confluent. This is sometimes apparent when plants have been topped too low and the leaf surface having thereby been reduced too much, the leaves remaining on the plant are unable to deal satisfactorily with the nitrogen available. Where the area of an old hogpen occurs in a field, the rank coarse plants upon it are easily discernible.

In general, the amount of ammonia supplied in an artificial fertilizer is not greater than 3 or 4 per cent. It is considered that the sources of nitrogen should be varied. Where a fertilizer containing 3 per cent. of nitrogen is used, in general one-third of the

nitrogen is supplied by nitrate of soda, one-third by cotton-seed meal, and one-third by fish scrap. Sodium nitrate is more highly thought of than ammonium sulphate, and cotton-seed meal is more highly thought of than dried blood. Cotton-seed meal is regarded by some as a very desirable constituent. Mixtures containing one-fourth nitrate of soda, one-fourth ammonium sulphate, one-fourth cotton-seed meal, one-fourth fish scrap, have given good results. It is recognized that a plant may take up the radical containing the nitrogen and leave the remaining radical of a salt. Thus land continuously fertilized with sodium nitrate would have a tendency to become alkaline, while land continuously fertilized with ammonium sulphate would have a tendency to become acid.

While rotation of crops is recommended in tobacco growing, the use of some leguminous crops as a source of nitrogen appears to be positively harmful. Thus, at the Oxford Tobacco Station, vetches have been shown to be a very undesirable leguminous crop. Tobacco seldom does well after maize, which takes too much out of the soil. A general rotation is tobacco, maize, cow-peas, oats. At the Oxford Station urea has proved a very satisfactory source of nitrogen, cyanamide not very satisfactory, and potassium nitrate unsatisfactory.

(*c*) *Potash.*—It is stated in all modern books on botanical physiology that potash is thought to be in some way connected with the formation of starch. Anything more definite than this is hard to find. That a supply of potash is necessary for the tobacco plant: (*a*) to promote the production of a large healthy leaf surface; (*b*) to produce good burning qualities in the leaf, is well recognized by American authorities. They recognize, also, certain symptoms in regard to the supply of potash:—

1. If the ends of the leaves turn downwards and curl under, and the edges of the leaves curl downwards and inwards toward the mid-rib, the supply of potash is deficient.

2. If the leaf is broad, healthy, with plenty of body, dark green and corrugated near the veins, the supply of potash is sufficient; if this condition is exaggerated, too much potash has been used.

3. If potassium muriate has been used as one of the sources of potash and the ends of the leaves are yellow, the yellowness extending down the lamina toward the base, too much muriate of potash has been used.

4. If the leaf burns badly, due to too much chlorine, an excess of potassium muriate may have been used.

5. A young tobacco leaf is covered with hairs. As it matures these dry up, and, to a great extent, disappear. A leaf reaching maturity has a somewhat smooth appearance, which is desirable. This smoothness may be enhanced by manuring it with muriate of potash.

6. While this smoothness and the general texture of the leaf may be improved by the application of muriate of potash as a fertilizer, not more than 2 per cent. of the potash used should be derived from muriate of potash, or the burning qualities of the leaf are likely to be impaired.

7. Too much muriate of potash causes young tobacco plants to become brittle and the edges of the leaves to curl upwards.

Owing to the action of chlorine in impairing the burning qualities of the leaf, the question of the source of potash becomes one of great importance. The relative amount of chlorine in a fertilizer to the amount of potash it contains may be so great as to bar its use as a source of potash for tobacco. Thus, kainit and manure salts (a cheap form of manure containing potash) contain altogether too much chlorine to every unit of potash to make them possible as sources of potash for tobacco culture.

It is held generally that potash manures confer upon tobacco a certain amount of protection from disease. (This view is held elsewhere also; potash is said to protect potatoes from Irish blight and roses from mildew).

Potash may be used in a mixed fertilizer at the rate of from 3 to 8 per cent. It is preferable to use it as a mixture of sulphate and muriate of potash, and to obtain, thus, in the leaf, some of the good qualities due to each. However, not more than 2 per cent. of the potash used should be derived from muriate of potash, owing to the fact that too much chlorine impairs the burning qualities of the leaf.

(*d*) *Magnesium and Calcium.*—The role of calcium in tobacco culture is not definitely known. A quantity of it is always supplied in the form of sulphate when superphosphate is used. It has been found that the tobacco plant needs to be supplied with magnesium. As it is a foliage crop, and as magnesium is a definite constituent of chlorophyll, this is not surprising. Want of sufficient magnesium in the soil is most apparent in crops grown in poor land. The leaves show poor development, the leaf tips and the lamina, especially towards the apex of the leaf, become of a pale-yellow colour. This physiological disease is known as "Sand Drown." The remedy is to apply magnesium limestone at the rate of 1 ton to the acre a month before planting. Such an application once every three years is often sufficient to supply the necessary magnesium. It is magnesium, and not calcium, that the plant requires, but magnesium limestone is the most easily available source of the element required.

The value of the manures referred to is determined by a carefully devised series of experiments which are carried out in duplicate or triplicate at the Oxford Tobacco Station and upon numerous demonstration plots on different soils through the State. The tobacco is harvested by priming and cured. It is classified into lugs, or basal leaves (common, medium, best), leaf (common, medium, best), and tips (red, green). The weight of each and the value of each is determined. The increase in value of the crop brought about by the use of fertilizers is determined. A survey of these figures enables the operator to determine the value of a fertilizer, and in what portion of the plant its influence has been most felt. It is recognized that it is of no use to attempt to determine the value of an element by the use of one fertilizer only containing that element. The plant must be supplied at least with a complete fertilizer to work on, and then the influence of an excess of any element can be determined by increasing the amount of it in the basic complete fertilizer used.

The Imperial Agricultural Research Conference, October, 1927.

By Professor A. E. V. Richardson, Director, Waite Agricultural Research Institute, University of Adelaide.

Professor Richardson was one of the Australian delegates to the Conference. The others were Mr. G. A. Julius, Chairman of the Council, and Dr. S. S. Cameron, Director, Victorian Department of Agriculture.—Ed.

1. General.

The Imperial Agricultural Research Conference was held in London from 4th-29th October, 1927. About 170 delegates, representative of all the Dominions, seventeen Crown colonies, the Ministry of Agriculture, and the principal agricultural institutions in Great Britain, attended. The main purpose of the Conference was to discuss the needs of the Empire in regard to the development of agricultural research and the methods whereby Imperial co-operation in agricultural research might be effected.

Three important administrative questions were discussed in detail:—

(*a*) The recruitment, training, and interchange of workers for agricultural services and for agricultural research.

(*b*) The establishment of a chain of research stations to serve the needs of the tropical and sub-tropical parts of the Empire.

(*c*) Imperial co-operation in the interchange of information in various branches of agricultural science.

In addition, twelve technical committees were set up, and the needs of practically every branch of agricultural science were surveyed. These technical committees were concerned with the subjects of animal nutrition, animal genetics, veterinary science, soil problems, plant genetics, dairying, horticulture, agricultural economics, entomology, plant pathology, preservation of food, and cool storage. The Conference was an advisory, and not an executive, body. The carrying out of its recommendations depends on the co-operation of the various Governments of the Empire, and their willingness to act on the recommendations of the Conference.

2. Recruitment, Training, and Interchange of Workers.

The Conference surveyed the question of man power in relation to agricultural research. It affirmed that agriculture was by far the largest industry in the Empire, and upon its enhanced productivity, through the application of science, depended the prosperity of the commonwealth of nations constituting the British Empire; that the progress of scientific research in agriculture and its effective application to agricultural development depended ultimately on an adequate supply of well-trained scientific men; and that to obtain the highest efficiency in the agricultural services it was essential to attract candidates of the highest class, and to equip them with the best possible scientific and technical training. It was shown by the Conference that the primary reason for the existing shortage of scientifically trained officers for the agricultural services was the wholly inadequate appreciation of the importance and value of scientific research by the public,

the press, and even Governments. It was shown that, at the present time, there was an acute shortage of first class research workers, especially in those branches of agricultural science requiring a training in the biological sciences, e.g., entomology, mycology, animal and plant genetics, animal nutrition, agrostology, dairying, &c. Temporary measures, such as scholarship schemes, might overcome this shortage, but it was felt that the only permanent solution was to make the agricultural services in respect to emoluments, facilities for work, opportunity for a career, &c., at least as attractive as other services carrying equal duties and responsibilites.

The question of type of training for the agricultural services was dealt with in detail. The Conference considered that for the specialist or research officer a sound honours' training in science, including at least one biological subject, was the first essential. The second was such a knowledge of agriculture as would enable him to appreciate clearly the role of science in agriculture. For the general or administrative officer, wide agricultural knowledge, a practical outlook, and administrative ability was regarded as the first requirement. The second was considered to be scientific knowledge adequate for the full utilization of scientific results in agriculture, and for close collaboration with specialist colleagues. Broadly speaking, the standard for the former officer should be an honours degree in pure science; in the latter case, a University degree in agriculture, supplemented in both cases with suitable post-graduate training.

The Conference emphasized the necessity of encouraging biological studies in the Universities. Men with a biological outlook are required for many branches of agricultural science, e.g., entomology, mycology, genetics, animal nutrition, &c. In the opinion of the Conference, the predominance of the physical sciences over the biological sciences in all educational institutions, from the elementary schools to the Universities, was one of the gravest difficulties in the supply of officers for the agricultural services.

With regard to recruitment, the Conference discussed the question of instituting an Imperial scholarship scheme, but decided that at present a unified scheme would be impracticable. It was considered highly desirable and quite practicable to effect an interchange of workers on an Imperial basis, and that this interchange might well be carried out through the proposed Imperial bureaux that are to be established.

3. Chain of Research Stations.

The Conference surveyed the whole of the tropical and sub-tropical parts of the Empire as a field for organized research. It recommended the establishment of a series of central tropical and sub-tropical research stations, located at convenient centres, where groups of related problems could be advantageously investigated for the benefit of the whole Empire. Such stations would be financed partly from Imperial sources and partly by the Governments of the territories which they would serve.

The establishment of such a chain of research stations was approved by the last Imperial Conference. Two of these tropical research stations have already been established—namely, Trinidad and Amani in Tanganyika. Consideration was given by the (Agricultural) Conference to the establishment of similar stations in Northern Australia, East Africa,

West Africa, Ceylon, and the Federated Malay States. The Conference defined the needs which these stations were to meet, the scope and character of the work they should undertake, and their relationship to the various Government Agricultural Departments. It affirmed that they should, in the main, confine themselves to long-range and wide-range research; that, in general, they should concentrate on (i) problems requiring more prolonged reseach than could normally be expected from any single Department of Agriculture, and (ii) on problems affecting more than one territory of the Empire; and that they should not conflict or compete with the work of Departments of Agriculture, but rather that their work should be complementary and supplementary to the work of such local Departments.

The Conference did not consider that these research stations, as such, should be expected to undertake any teaching work, except in so far as the advanced instruction of a limited number of post-graduate students could be undertaken with advantage to the research work in progress. It considered that no general rule could be laid down as to the form of control most appropriate for a central research station, but confined itself to expressing the opinion that the control of the station should be such as to ensure that the institution should not be diverted from a programme of free research. Moreover, the Conference recognized that the control of any station established in a self-governing Dominion must be left to the oversea Government concerned.

So large a part of the tropical and sub-tropical areas of the British Empire lies within the Colonial Empire that the majority of these stations must be located in the Crown Colonies.

The Conference made two further recommendations regarding the chain of research stations:—

(i) The establishment of a central research station in connexion with the diseases of animals.

(ii) The establishment of a new research station to deal with scientific problems associated with irrigation and irrigated agriculture.

In regard to the station for irrigation, the Conference recommended the immediate appointment of a sub-committee of the Committee of Civil Research to investigate and report upon the question of establishing such a station.

4. Imperial Co-operation in the Interchange of Information.

The Conference examined in detail and prepared plans for a considerable extension of the existing machinery for co-operation between agricultural research workers throughout the Empire. It recommended the establishment of Imperial bureaux for animal health, soils science, and animal nutrition; and Imperial Correspondence Centres for animal breeding, plant breeding, horticulture and agricultural parasitology. These bureaux and correspondence centres would function in the same manner as the existing Bureaux of Mycology and of Entomology, and would act as clearing stations for the collection, classification, and dissemination of information of a scientific and technical character for workers in these subjects throughout the Empire. They would also reply to inquiries on scientific and technical problems from Agricultural Departments and scientific workers in any part of the Empire, and facilitate intercourse among groups of workers on closely allied problems.

The Conference considered that the number of workers and the output of literature throughout the Empire for the subjects of soil science, animal nutrition, and animal health justified the establishment of clearing stations on the scale of bureaux. The locations of the bureaux were considered by specialist committees, and on their advice the following recommendations were made:—

(i) A Bureau of Soil Science to be attached to the Rothamsted Experiment Station.

(ii) A Bureau of Animal Nutrition to be attached to the Rowett Research Institute, Aberdeen.

(iii) A Bureau of Animal Health to be established in London.

The importance of an interchange of information on animal health was considered to be so great that the Conference recommended the immediate establishment in London of a bureau to deal with such problems, and to include and absorb the section dealing with tropical animal diseases now comprised in the Bureau of Hygiene and Tropical Diseases.

In addition to these bureaux, the Conference recommended that Correspondence Centres should be established on the following subjects, but on a smaller scale than in the case of the Bureaux:—

(i) Animal Genetics.—At the Animal Breeding Research Department, Edinburgh University.

(ii) Plant Genetics.—

At the Plant Breeding Institute, Cambridge University (to deal with all crops except herbage plants).

At the Welsh Plant Breeding Station, Aberystwyth (to deal with herbage plants).

(iii) Fruit Production.—At the East Malling Research Station, Kent.

(iv) Agricultural Parasitology.—At the Institute of Agricultural Parasitology, London.

The Conference considered that the time was not yet ripe for correspondence centres in agricultural economics, dairying, food preservation, and transport problems, or in economic botany.

The Conference considered that the cost of the bureaux and correspondence centres recommended would be £20,000 per annum for a period of five years. It recommended that funds available for the establishment and development of these bureaux should be administered by an authority representative of the contributing Governments.

5. Technical Committees.

The needs of practically every branch of agricultural science had been surveyed by specialists of twelve sub-committees, and valuable reports were submitted by these committees as to the best means of promoting research in these fields. The subjects included animal health, animal nutrition, animal genetics, soils, dairying, entomology, mycology, horticulture, plant breeding, agricultural economics, preservation of food, and cold storage problems. Any number of recommendations were made by these technical committees. Among these was a recommendation, endorsed by the Conference, for the provision of funds for the intensive study of the fundamental nature of virus diseases in plants.

6. Next Meeting of the Conference.

The Conference accepted the invitation of the Prime Minister of Australia to hold the next Conference in Australia, in the year 1932.

The Prevention of Tuberculosis in Cattle.

An Investigation to Determine the Value of the B.C.G. Vaccine for the Prevention of Tuberculosis.

By Professor H. A. Woodruff, M.R.C.V.S., and T. S. Gregory, B.V.Sc., Veterinary Research Institute, University of Melbourne.

Professor Woodruff is the Director of the Melbourne Veterinary Research Institute, and Mr. Gregory is an officer of the Council who has been accommodated at the Institute by kind permission of the authorities concerned.—Ed.

1. General.
2. Experiments to determine the degree of virulence possessed by B.C.G.
3. Experiments to determine whether B.C.G. increases in virulence after passage through animals susceptible to tuberculosis.

1. General.

Of the many attempts which have been made to discover a method of protecting animals against infection with tuberculosis, the production of a vaccine by Calmette and Guerin is one of the most noteworthy, because of the eminence of the authors and their previous outstanding work in relation to tuberculosis.

The claim of these authors to have elaborated a vaccine, efficacious as a preventive agent, both in human beings and in animals, requires very thorough investigation under the various conditions to which cattle are subjected. The value of a reliable protective method for human use is incalculable, but even in relation to cattle the use of such an agent would be of great economic value in preventing the very considerable losses due to tuberculosis, and, further, the improved health of cattle would have a substantially good effect on human health. It is important to remember that tuberculosis of cattle is very nearly related to tuberculosis of man, that it is transmissible to man, and that results following the use of a vaccine in cattle, whether beneficial or harmful, are probably entirely applicable to its use in the human being.

This preliminary report refers to a series of experiments on calves in this Institute during the latter part of 1926 and 1927.

The Vaccine.—The vaccine consists of a suspension of living but attenuated tubercle bacilli, whose lowered virulence has been brought about and fixed by Calmette and Guerin as a result of cultivation through many generations, during more than thirteen years, on a special medium containing ox bile. This fixed attenuated strain of *B. tuberculosis* is now known as Bacillus Calmette-Guerin, or simply B.C.G. These authors claim that, neither by prolonged culture on ordinary media suitable for the tubercle bacillus, nor by repeated passage through susceptible animals, will its virulence be again exalted so as to make it dangerous. No curative properties, but only preventive ones, are claimed for the vaccine; and its use is confined to young, preferably newly-born, children or animals, before any serious opportunity of infection with tuberculosis can have occurred. The principle underlying the preparation and use of this vaccine, as stated by Calmette, is that a mild localized infection with tuberculosis will, so long as the causal organisms remain alive, act so as to prevent a fresh natural infection with the disease. For example, children who have had a chronic tubercular lesion in the glands of the neck very rarely become affected with

phthisis later in life. Again, cattle with a small localized tubercular lesion will resist a new infecting dose of tubercle bacilli sufficient to infect and eventually kill any healthy non-tubercular ox.

Acting on this assumption, for which much evidence can be marshalled, Calmette has endeavoured to elaborate a strain of tubercle bacillus which, when injected subcutaneously in the new-born calf, will remain alive for a long period, but will not produce any tubercular lesions beyond the site of the inoculation. Such a procedure does not amount to immunization, for the injected tubercle bacilli continue to live for more than twelve months at the site of inoculation, but to a state of "premunization" in that the calf will resist natural infection with tuberculosis, even in a tubercular atmosphere, so long as the vaccine remains alive.

It will be readily realized that the use of such a live vaccine, whether in children or animals, can only be advocated if after thorough testing it is proved incapable, under any circumstances, of setting up a progressive tuberculosis. Calmette and Guerin have themselves submitted the vaccine to a prolonged series of tests in the smaller laboratory animals, as well as in cattle, in the higher apes, and finally in children. The publication of their results evoked world-wide interest and a repetition of the tests by many other investigators in other countries by the courtesy of Calmette and Guerin.

Early in 1926, in response to a request by one of us, Professor Calmette very kindly forwarded, free of all charge, cultures of B.C.G. to this Institute, only stipulating that the produce "should not be sold or commercialized." A number of subcultures were obtained, and a series of experiments involving the vaccination of several calves was at once commenced.

Shortly afterwards, this work was included in the programme being undertaken here at the request of the Council for Scientific and Industrial Research, and since the appointment of one of us (T. S. Gregory) as a veterinary research officer by that body, the further investigation has been a collaboration. Professor Calmette kindly forwarded further details with regard to the preparation of the vaccine, and in the meantime a number of papers on the subject of this vaccine have already appeared in the literature.

The investigation here recorded has been mainly concerned with—

(i) The determination (*a*) of the innocuity of the original B.C.G. culture as received, and (*b*) of its continued virulence after subculture and after passage through animals susceptible to tuberculosis.

(ii) The power of B.C.G. vaccine to prevent the development of generalized tuberculosis as a result of the injection of virulent bovine tubercle bacilli into the jugular vein of calves previously vaccinated.

(iii) Observation of the special cultural and other characters of the B.C.G. This has been incidental to the former two lines of work.

With regard to these last observations, it may be said that the B.C.G. organism grows readily on the usual media used for the cultivation of *B. tuberculosis*. For general use, slices of potato are soaked for one hour in glycerine broth, then placed in constricted tubes which contain glycerine broth (pH=7.2) up to the constriction. The tubes

are sterilized by autoclaving, and after the potato slopes have been sown with B.C.G. they are inclined at about an angle of 30° on a special rack, in order to ensure that the slopes are kept in contact with the broth. Growth on such medium is very abundant. An excellent growth also takes place on Dorset's egg medium which is maintained in the inclined position.

Of the fluid media, the synthetic medium of Sauton* is most useful. As recommended by Calmette and Guerin, cultures are resown not later than every 25 days; and at every tenth subculture three successive cultures are made on potato, in order to maintain the special characteristics of the organism. Cultures are kept at 38° C. in a special incubator and room, in order to minimize any danger of contamination with virulent tuberculosis organisms.

But now turning to the more important part of the work we shall proceed to describe—

2. Experiments to Determine the Degree of Virulence possessed by B.C.G.

(*a*) *The Preparation of the Vaccine.*—The material used for inoculation has been prepared in accordance with the directions of the authors. A small amount of culture on glycerinized potato is transferred on to the surface of Sauton medium (pH=7.2) contained in a shallow flat-bottomed flask of 300 c.cs capacity, and incubated at 38° C. The subsequent growth will usually cover the surface in ten days, and thereafter gradually becomes thicker and wrinkled. At some time prior to the 25th day of cultivation, this surface growth is carefully removed by means of a sterile glass grid, and after being pressed between folds of sterile filter paper, is weighed in the humid state on a piece of filter paper of known weight. Five hundred milligrammes of the culture are then placed in a strong flask in which are sufficient solid glass beads of various sizes to cover the bottom, the flask and beads having been previously autoclaved. A quantity of 100 c.cs. of a 1 in 4 dilution of Sauton medium in normal saline is added very gradually, and, as a result of prolonged shaking of the flask and the attrition of the culture by the beads, an even emulsion is obtained containing 5 milligrammes of living bacilli per 1 cubic centimetre.

(*b*) *Experiments with Calves.*—A number of calves, nineteen in all, have been vaccinated, each within a few days of birth. In each case the live culture, prepared as above, was injected just under the skin in the dewlap. Three received 25 milligrammes, twelve 50 milligrammes, and four 75 milligrammes, each as a vaccinating dose. As a result of inoculation there is produced within 48 hours a well-defined firm nodule about the size of a walnut, but in no case did any calf show the least sign of sickness. With the exception of those which were affected with intercurrent infections, normal growth continued, and they were in every way as apparently healthy as uninoculated control calves reared under the same conditions. A gradual diminution in the size of the nodules was noticed.

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* Sauton Medium—

	Grams per Litre.
Asparagine	4
Pure glycerine	60
Citric acid	2
Dipotassium hydrogen phosphate	0·5
Magnesium sulphate	0·5
Iron and ammonium sulphate	0·05
Water	940

After weaning, the calves were turned out at pasture, and had to withstand drought conditions. Five of the nineteen calves died of intercurrent infections at intervals of one, two, two, four, and seven months respectively after inoculation. In all cases the cause of death was enteritis. Detailed post-mortem examinations were made. The nodules at the site of inoculation varied in size from that of a pea to that of an acorn. In each case there was a small amount of purulent material encapsuled in fibrous tissue and containing numerous acid-fast bacilli. There was an entire absence of any other lesions of tuberculosis in any part of the body.

The remaining fourteen calves continued to grow equally as well as normal uninoculated calves on the same pasture.

(*c*) *Experiments with Guinea-pigs.*—At each time of vaccination of calves a control inoculation with the same emulsion was always carried out, using two guinea-pigs. This was for the purpose of proving the continued avirulence of the live culture used as vaccine. The results have completely demonstrated the innocuity of B.C.G. for guinea-pigs. Thus in the series which was inoculated with 3 milligrammes of B.C.G., and of which series members were killed at intervals of 1, 2, 3, 4, 5, and 6 months after injection, not one animal showed any signs of tubercular infection apart from the trace, and that only in some, of the abscess produced at the site of inoculation. All these animals had grown and increased in weight at a normal rate. Similar results were obtained in the series inoculated with 5 milligrammes of B.C.G.

The only apparent result of inoculation was the production at the site of injection of a small abscess, which in some cases burst and then healed up, whilst in others it remained for a varying length of time as a small nodule containing a little pus, in which were the typical acid-fast organisms.

(*d*) *Experiments with Rabbits.*—Rabbits have been inoculated subcutaneously with 5 milligrammes, 7.5 milligrammes, and 10 milligrammes respectively of the B.C.G., and then killed and examined after four months, seven months, and six months. Without exception, these animals were in good condition, and showed no symptoms of sickness. On post-mortem, rabbit No. 62 (dose 5 milligrammes) had only a small nodule containing inspissated pus, the whole being as large as a split pea, at the point of inoculation. No other pathological lesions could be discovered. The other rabbits, No. 61 (dose 10 milligrammes) and No. 66 (dose 7.5 milligrammes), both had a soft cold fluctuating abscess the size of a small hazel nut just under the skin at the site of inoculation. The pus contained numerous acid-fast bacilli.

In none of the three animals could any other lesions of tuberculosis be found microscopically, nor could any acid-fast bacilli be demonstrated microscopically in lymph glands or viscera.

(*e*) *Experiments with Sheep and Fowls.*—Although the sheep is only in extremely rare instances affected naturally with tuberculosis,(1) this animal is by no means insusceptible to experimental infection. It was therefore thought desirable to test the degree of virulence of B.C.G. on this animal. In the case of the fowl, avian tuberculosis is quite common, the avian bacillus having special characteristics which differentiate it sharply from both human and bovine tubercle bacilli.

(1) Neither of the writers has ever seen a case of naturally-acquired tuberculosis in the sheep in Australia.

Inoculation of suitable doses of B.C.G. subcutaneously in these animals, both sheep and fowls, produced no ill effects, but only a small local reaction in the form of the usual nodule containing pus with acid-fast organisms in it. These nodules gradually disappeared.

Conclusions.—The foregoing experiments agree entirely with the claims of Calmette and Guerin that B.C.G. is quite innocuous for cattle, sheep, rabbits, guinea-pigs, and other small animals, even when introduced in relatively enormous doses. It has been estimated that less than 50 virulent tubercle bacilli will set up progressive fatal tuberculosis when injected subcutaneously in a guinea-pig, whereas in these experiments guinea-pigs have been inoculated with 200,000,000 living B.C.G. organisms without the production of any progressive lesions.

3. Experiments to Determine whether B.C.G. Increases in Virulence after Passage through Animals Susceptible to Tuberculosis.

A series of experiments has been carried out on guinea-pigs to determine this point. It will be remembered that the B.C.G. vaccine has been used on a number of calves—several of which died or were killed without having been submitted to any immunity test by means of inoculation with virulent tubercle bacilli. From each of these calves—five in all—material was obtained either in the form of purulent matter from the original nodule set up by the B.C.G. vaccine, or in the form of lymphatic gland substance from glands in the vicinity of the site of vaccination. The purulent matter from the nodule contained in every case acid-fast bacilli. There were no other lesions anywhere in the body, so that it may be assumed that these bacilli were, in fact, B.C.G. organisms inserted at the time of vaccination.

These organisms had been living in the subcutaneous tissue of the calves for the varying periods set out in section 2 of this report. The gland substance was taken from neighbouring glands—axillary, prescapular, bronchial, and mediastinal—on the supposition that some living B.C.G. organisms might have been transported in the lymph stream or by phagocytes to these glands from the site of vaccination, and might still be viable. Guinea-pigs were inoculated from these two sources in the case of each of the five calves. They were observed for varying periods of one to several months, and then killed for examination. In all cases growth was normal; no symptoms of ill health were shown; no glands were palpably enlarged during life; and in no case were any lesions suggestive of tuberculosis found.

The results of these experiments indicate that there is no increase in the virulence of B.C.G. re-inoculated into susceptible animals after having existed in cattle for periods of up to six months.

The Effect of the Virulence of B.C.G. of Repeated Subculture on Ordinary Artificial Media.—B.C.G. has been carried to the twelfth subculture on the ordinary media not containing bile, such as is used for cultivating *B. tuberculosis,* and it has shown no increase in virulence as tested by the inoculation of healthy cattle and guinea-pigs.

The Determination of the Protective Properties of B.C.G. against Infection with Virulent Tuberculosis Bacilli.—A number of calves have been vaccinated, and later inoculated with virulent tuberculosis bacilli intravenously. These experiments are incomplete, and will be reported upon when final results can be tabulated.

The Cattle Tick Pest in Australia.

By R. P. M. Short, Secretary, Cattle Tick Dip Committee, Council for Scientific and Industrial Research.

1. General.
2. Operations of Cattle Tick Control Commission.
3. Investigations of the Cattle Tick Committee in Queensland.
4. Scheme of Investigations already carried out.
5. Results of Investigations.
6. Present and Projected Activities of Cattle Tick Dip Committee.

1. General.

The problem of the minimization of the cattle tick and, if possible, its elimination from Australian herds, is of primary importance to the cattle industry of the Commonwealth if that industry is to be placed on a scientific and profitable basis. Advantages to be derived from a successful campaign against the tick will not only be confined to the stock owners, but will extend to the dairy, tanning and other subsidiary industries.

The late Advisory Council of Science and Industry (1) at the outset of its activities, gave consideration to the adoption of measures to deal with the pest, and it published two bulletins (2) on the subject. A special Cattle Tick Dip Committee was appointed in 1918 to ascertain and collect scientific data in respect of dipping fluids, their potency in relation to the destruction of tick life, and the effect of dipping upon treated animals. Stock owners are largely concerned in these problems, relating as they do to the prevention of the spread of ticks to non-infested areas, and to the application of restrictions imposed by the State Governments on interstate and intra-state movements of stock.

It is the intention of the Council for Scientific and Industrial Research to convey this information in a popular form to those principally interested, with a view to securing more intensive co-operation than has heretofore prevailed between graziers and farmers on the one hand, and Government authorities on the other. At the present time the activities of the Commonwealth in respect to the cattle tick are primarily centred on the operations of the Cattle Tick Control Commission and the Tick Dip Committee, but mainly on the latter. In this article the operations and investigations of the Commission and the Committee are briefly outlined.

2. Operations of Cattle Tick Control Commission.

A provisional Committee, representative of the Governments of the Commonwealth and the States of New South Wales and Queensland, concluded some time ago that there was every possibility of the eradication of the tick in parts of Australia if certain alterations and modifications were made in the procedure hitherto adopted which provided for individual effort by each of the States concerned. A recommendation was made that a Commission be appointed to exercise general direction and

(1) Now the Council for Scientific and Industrial Research.
(2) Advisory Council of Science and Industry Bulletins 1 and 13.

supervision over the operations incidental to eradication, and in particular to have authority to determine the following matters:—

(*a*) The areas in which eradication should proceed.
(*b*) The methods to be adopted in each area.
(*c*) The composition of dipping fluids.
(*d*) The intervals between treatments.
(*e*) The method of application.
(*f*) The conditions of the control of movements of stock, including straying and unattended animals.
(*g*) The conditions of enclosure of all grazing land.
(*h*) The location and erection of dips.
(*i*) The general expenditure.
(*j*) Such other matters as are considered essential for eradication.

The personnel of the Commission, which was appointed in October, 1926, is as follows:—

Dr. W. A. N. Robertson, D.V.Sc., Director of Veterinary Hygiene, Commonwealth Health Department (Chairman).

Max. Henry, M.R.C.V.S., Chief Veterinary Surgeon, New South Wales.

A. H. Cory, M.R.C.V.S., Chief Inspector of Stock, Queensland.

The Commission commenced to function on the 1st November, 1926, and operations under its jurisdiction are now in progress in New South Wales. The objectives of these operations are as follows:—

1. To arrest the extension of the tick in a southerly direction in New South Wales.
2. To take steps thereafter to eradicate the tick from the north-eastern districts of New South Wales.
3. Subsequently to extend the operations for control and eradication to tick infested areas in Southern Queensland.

The operations are not limited to any definite period of time, nor is there any limitation of the area to which they apply, as the ultimate objective is control and eradication in both States. A campaign is now in progress in New South Wales under the direction of the Commission, and in the meantime the work of control and eradication will still be carried out in Queensland on the lines hitherto employed and under the auspices of the Government of that State.

3. Investigations of the Cattle Tick Dip Committee in Queensland.

In 1918, a proposal was made by the late Institute of Science and Industry for the establishment of a special committee to superintend investigations into cattle tick dips in relation to tick control and eradication. Ultimately (in December, 1919), it was decided that the proposed committee should be formed and that it should have its headquarters in Brisbane. The committee was accordingly constituted as follows:—

G. E. Bunning (Chairman)	Representing the Commonwealth Council for Scientific and Industrial Research.
Dr. W. A. N. Robertson, D.V.Sc., Director of Veterinary Hygiene, Commonwealth Department of Health	
Dr. E. J. Goddard, B.A., D.Sc., Professor of Biology, University of Queensland	

J. C. Brunnich, Agricultural Chemist, Queensland .. .. .. A. H. Cory, M.R.C.V.S., Chief Inspector of Stock, Queensland .. .. C. J. Pound, Government Bacteriologist and Director of the Yeerongpilly Experiment Station, Queensland ..	Representing Queensland.
A. A. Ramsay, Chief Agricultural Chemist, New South Wales .. .. Max. Henry, M.R.C.V.S., Chief Veterinary Surgeon, New South Wales .. C. J. Sanderson, M.R.C.V.S., Chairman, Board of Tick Control, Lismore, New South Wales .. .. .. L. Cohen, Chemist, Board of Tick Control, Lismore, New South Wales ..	Representing New South Wales.

It was decided to conduct investigations in conformity with those suggested at the Conference of Delegates appointed by the Institute of Science and Industry, as set out in Bulletin No. 13 which reads as follows :—

"Although the present official formulæ used in Queensland and New South Wales have proved to be efficient and generally satisfactory, it is possible that the same parasiticidal results might be maintained, and the ill-effects that sometimes occur obviated, by alteration of the composition of the agent.

"There is evidence that solutions containing a lower arsenical content than officially stipulated are effective in the hotter parts of Queensland. It is possible that it will be found that the strength of the parasiticide used may with safety be varied according to the time of the year, and the climate of the locality where it is used. With a view to determining the limitations, experimental investigation is deemed necessary."

4. Scheme of Investigations already Carried Out.

Experiment No. 1.—The action of standard arsenical dip fluid on ticks during the moulting stage.

Experiment No. 2.—The extent, if any, of the protective action of medicaments against re-infestation by larval ticks.

Experiment No. 3.—The effect of subsequent rainfall on the efficacy of treatment.

Experiment No. 4.—To test the comparative effect of two applications of dipping fluid at short intervals, and at strengths of four, five and eight pounds of arsenious oxide per 400 gallons of water.

Experiment No. 5.—To determine the minimum amount of arsenic (combined with soap and tar) necessary to kill all ticks with two sprayings.

Experiment No. 6.—To investigate the effect of the omission of emulsion from the official formula.

Experiment No. 7.—To ascertain whether the efficacy of the dipping fluid is diminished by continuous use (the percentage of arsenious oxide remaining constant).

Experiment No. 8.—To find a substitute for Stockholm tar, which varies considerably in composition and is difficult to obtain.

Experiment No. 9.—To ascertain whether a decreased amount of arsenic can be compensated for by an increased amount of Stockholm tar or substitute therefor. (It is considered that to a certain extent any injurious effect of the dip must be in proportion to the quantity of arsenic, whereas soap and emulsions have an emollient effect).

Experiment No. 10.—Although many concentrates give good results when freshly prepared, it is a well-known fact that the liability to oxidation varies. Concentrates which show exceptional liability to oxidation cannot be recommended for general use in substitution for the official formula. It was therefore decided that before the experiments were conducted on cattle, the comparative oxidation should be first determined on a laboratory scale. For this purpose it was arranged that small quantities—approximately 4 gallons—of the various standard strength commercial concentrates approved under Government Regulations be exposed to the air after the addition of a small amount of bovine excreta, and the rate of oxidation determined by periodical analyses.

Experiment No. 11.—The prevention of oxidation of dipping fluid.

Experiment No. 12.—A test of Derris Root (Tuba Root) or its manufactured products, as a tick destroying agent.

5. Results of Investigations.

A summary epitomizing the findings of the Tick Dip Committee, based on the investigations carried out, is as follows:—

(*a*) The field experiments showed that at Tallebudgera, where the experimental cattle had to be driven some two miles to the dip and the weather was hot and humid, epidermal exfoliation (scalding) took place even at the lowest arsenical strength employed; whereas at Oxenford, where the weather during the experiment was cold and the cattle were depastured on the holding on which the dipping took place, no scalding was noted. This would support the view that dipping in arsenical solutions *per se,* used in the concentrations commonly employed, does not cause injury to the skin unless other factors, such as humidity or driving prior or subsequent to dipping, are present.

(*b*) No single treatment with fluids of concentrations of from 4 lb. to 10 lb. arsenious oxide per 400 gallons or containing up to five times the prescribed standard proportion of saponified tar, is efficacious in destroying all ticks in all stages of development on an infested animal, and further, during the second moulting period of a tick's parasitic life, a phase exists in which the tick is resistant to the action of arsenical fluids. The existence of surviving adult females after treatment is apparently due to this phenomenon. Some survivors lay a full complement of eggs which duly hatch.

(*c*) Treatment with the prescribed standard arsenical fluid as set out in paragraph (*e*) below affords protection against re-infestation by larval ticks for a period of two days.

(*d*) Heavy rain falling on cattle more than two hours subsequent to treatment, provided that the cattle had become dry in the interim, does not diminish the efficacy of such treatment.

(*e*) While two treatments, at an interval of two or three days, with medicament containing 8 lb. of arsenious oxide, half-a-gallon of Stockholm tar and 5 lb. of potash soap to 400 gallons, do not actually kill all the ticks present on an animal at the time of the initial treatment, they are successful in preventing the propagation of such ticks by destroying the fertility of the resultant eggs.

(*f*) The result of the experiments indicates that the minimum proportion of arsenious oxide (in conjunction with Stockholm tar and potash soap) necessary to prevent the propagation of all ticks by two sprayings of the animals at an interval of three days, is 8 lb. per 400 gallons.

(*g*) The omission of Stockholm tar and soap from the dipping fluid diminishes the efficacy of that fluid as a tick destroying agent, but, weight for weight, soap is not an efficient substitute for Stockholm tar. Resin can be used as an efficient substitute for Stockholm tar, 4 lb. of it having been found to be more effective than half a gallon of tar.

(*h*) Oxidation in dipping baths can be prevented or rectified by the addition of 2 per cent. skim milk or butter milk, or an equivalent amount of casein or dried butter milk.

6. Present and Projected Activities of the Tick Dip Committee.

The adoption of uniform and yet efficacious methods for the cleansing of cattle in the Australian States concerned is a particularly important matter. To secure this uniformity, and to justify the co-operation of stock owners, it is essential that information based on conclusive investigations should be supplied showing that any dipping restrictions imposed are such that their adoption would result in obtaining a maximum of results at a minimum risk to the cattle treated. This specially applies in dairying districts where the cattle are the main and immediate source of income to the farmer. To achieve the objective indicated, it is necessary that experiments under natural conditions should be carried out in a suitable location where the isolation of the experimental cattle can be provided for in order to determine (i) the most suitable interval between dippings and (ii) the optimum composition of the dipping fluid, by observing the time required to eradicate all ticks on infested cattle. Suitable experimental paddocks have been secured at Samford, near Brisbane, and investigational work is now about to be initiated.

It has been arranged that the following solutions and intervals should be adopted:—

(*a*) 8 lb. arsenious oxide at an interval of fourteen days.

(*b*) 6½ lb. arsenious oxide at an interval of eighteen days.

Progress reports on the operations will be furnished as they become available.

"Walkabout," or Kimberley Horse Disease.

By D. Murnane, B.V.Sc.

Early last year the Council arranged to co-operate with the State Department of Agriculture of Western Australia in an investigation of the "walkabout" disease that affects horses to a serious extent in the Kimberley District of that State. The services of Mr. Murnane, B.V.Sc., were utilized for the work. In addition, Professor A. J. Ewart, of the University of Melbourne, kindly undertook to accompany Mr. Murnane for part of the time, in order to carry out work on the botanical side. Mr. Murnane has now furnished the following short report on the work. As a result of the investigations, the cause of the disease has been definitely ascertained. It has been proved that the disease is due to horses feeding on a plant known as *Atalaya*, of which the common name is "Whitewood." As a similar, if not identical, disease occurs in other parts of Australia, and as the disease has been a very serious hindrance to the development of the Kimberley District, and has caused great loss to stock-owners, the results of the work are of very great economic importance. The eradication of the disease will present no very serious difficulties, and can be accomplished very largely by destroying *Atalaya* in the horse paddocks. In the case of large trees, it would be necessary only to lop off the lower branches. A full report on the investigations and on methods for combating the disease will be published later by the Council.—Ed.

1. General.
2. Description and Occurrence of the Disease.
3. Scope and Results of Investigations.

1. General.

Kimberley horse disease, or "walkabout" disease, as it is called locally, has been prevalent in North-west Australia for over 40 years. The disease has been commented upon from time to time by a number of veterinary scientists who have been stationed in the north, but the actual cause has remained a mystery until quite recently.

In 1926, the writer, a veterinary research officer, under the direction of the Council for Scientific and Industrial Research and of the Western Australian State Government, was stationed in the Kimberley District of Western Australia engaged on an inquiry into the buffalo-fly question. He became deeply interested in "walkabout," and in his spare time was able to carry out a considerable amount of work on the disease. After closely studying the symptoms and conducting numerous post-mortem examinations, he confirmed the opinion expressed by certain previous workers that the "disease" was due to plant poisoning.

This diagnosis was at first vigorously opposed by the majority of local stockmen, who held the idea that "walkabout" was caused by the presence of internal parasites (a common stomach worm known scientifically as *Habronema*). This idea had gained prevalence on account of the fact that few men in the district really knew the normal appearance of the inside of the stomach of the horse. Local people had been mistaking an entirely normal structure in the organ (namely, the two widely different types of mucous membrane or "lining") for a diseased condition supposedly brought about by the action of the stomach worm. This worm, as a matter of fact, is the most common parasite of the horse in all States of Australia, and is found to be equally as numerous in the stomachs of horses dying from other causes. The unique formation of the stomach "lining," together with the presence of numerous stomach worms, had given rise to the popular, but entirely erroneous, opinion that the stomach was the seat of the trouble.

On his return from the North-west, in 1926, the writer furnished the Council and the State Government of Western Australia with a report on the work which he had carried out.

2. Description and Occurrence of the Disease.

Description of the Disease.—An extremely fatal, non-infectious disease of the horse. (Cattle, sheep, donkeys, and mules are not definitely known to be affected. If they are affected, they show symptoms different from those of the horse.)

Occurrence.—The disease in Western Australia is confined to the Kimberley District. A very similar, if not identical, condition occurs in the Northern Territory. Further, J. Legg, B.V.Sc., M.R.C.V.S., Queensland, has described what appears to be an identical condition in that State. Diseases which appear to resemble the Australian condition very closely are also known to exist in South Africa, in New Zealand, and in North America.

In North-west Australia the disease occurs annually during the months of January, February, March, and April. The appearance of the disease usually coincides with the onset of the tropical "wet" season.

The Course of the Disease.—The disease may occur either in the acute, sub-acute, or chronic form. The sub-acute form is the one most commonly seen. Animals of all ages and both sexes are susceptible.

Symptoms.—These vary with the course of the disease. In the sub-acute or most common type, an animal may show signs of sickness for a few weeks or for a few hours only. The first symptoms noticed are that the animal is off his food, is dull, leaves the company of other horses, and stands alone in the corner of the yard or under a tree, with head down as if sleeping. Periodically the animal awakes and moves about grazing, but soon again assumes the sleepy attitude. The abdomen becomes "tucked up," the coat rough, and the eyes staring. The animal usually loses condition. It becomes irritable and persists in biting other horses, and gnawing at posts, bark of trees, &c. The appetite is depraved, and refuse and filth are eaten. Pregnant mares usually abort. Yawning is a marked and almost constant sign of the onset of the disease. Oedematous swelling of the limbs, prepuce, mammary gland, or lips is not uncommon.

Subsequently, in most cases, muscular spasms (very similar to those of strychnine poisoning) occur, usually followed by a sudden phase of mad galloping, in which the animal apparently has no sense of direction, and will not respond to efforts of control. This phase is transient, and soon passes off, leaving the animal apparently none the worse. These fits may recur naturally at intervals, becoming more frequent but less violent, until gradually they merge into the "walking" stage. Often there is a period following the "galloping" stage, when the animal appears to be quite normal. Sooner or later, however, comes the desire to move about, and constant walking is the most striking characteristic of this condition. The gait is slow, staggering, and aimless. The head is lowered and carried stiffly. The animal has difficulty in turning round, hence the peculiarity of walking in a straight line. Sight is certainly seriously impaired, if not totally lost. The corneal reflex is retained almost to the point of death. The pupil of

the eye is dilated, giving the eye a staring or "glazed" appearance. The animal walks stupidly into fences, trees, ditches, streams, or any objects which happen to be in its path.

Should progress be blocked by a fence, the animal will remain for hours obstinately pushing forcibly against it (see Plate 3, Fig. 1). The animal usually becomes bruised, and the skin and hair are torn from the head, body, and limbs by collision with obstacles. When standing, the horse often assumes abnormal attitudes (e.g., crossing of forelegs (see Plate 3, Fig. 2), continual swaying to and fro or from side to side is often observed. A peculiar feature, also, is the desire to reach some habitation. An affected animal will, if at all possible, wander to and enter a dwelling house if permitted to do so (see Plate 4, Fig. 1).

This "walking" stage is quite characteristic of the disease, and occurs in 50 to 75 per cent. of cases. The muscular spasms are present in practically all cases. Occasionally a horse will exhibit the early galloping phase without showing the subsequent walking signs, and vice versa. Dysphagia (or inability to swallow) is often noticed. An animal may walk about for hours with a mouthful of unchewed grass protruding from its lips. The subject may be unable to swallow even the saliva, which runs freely from the mouth. In the last stages, marked dyspnoea (abnormal respiration) is observed in practically all cases. "Roaring," due to laryngeal paralysis, often occurs also in the late stages. When death is imminent, the temperature becomes markedly elevated, and the respiration rate and pulse greatly increased. The urine is voided frequently, and in small quantities. It is usually highly charged with hæmoglobin. Visible mucous membranes are violently livid. Coma follows, and the animal staggers and falls. Involuntary spasms of the muscles of the head, neck, or limbs may develop. Death takes place usually without much struggling. Death is also frequently due to unnatural causes, being the result of misadventure while walking blindly about (e.g., drowning in rivers, strangulation in fences or forks of trees, falling over steep banks, &c.).

In the acute form of the disease the onset is sudden, and very little warning is given. An animal in excellent condition and in apparently good health may develop symptoms not unlike those of mild colic, and die suddenly. Usually the muscular spasms are observed, but the "galloping" and "walking" stages may be absent.

In the chronic form the onset is slow, but the affected animal is observed to be ill weeks or months before death takes place. The subject becomes unthrifty, and gradually loses condition, until it becomes a mere skeleton. The previous season's hair is not readily shed, giving the coat a rough appearance. The stockmen in the North aptly describe this as the "wasting" type of disease.

Mortality.—Few, if any, horses which become affected ever recover. When an animal goes down, or even reaches the walking stage, death invariably follows. The disease may be described as being 100 per cent. fatal. Odd animals have been known to recover temporarily, but they invariably die eventually.

Post-mortem Findings.—The striking feature in these cases is how little, and not how much, there is to see. The thoracic cavity with its contents is usually quite normal. The abdominal cavity and its contents, with the exception of the liver and kidneys, are likewise usually normal, or almost so. In some cases there is a marked oedematous

condition of the mucous membrane of parts of the digestive tract, while in other cases there is a congestion of the mucous membrane. The kidneys usually present a condition of congestion. The liver is the constant and chief seat of pathological change. The condition is essentially one of cirrhosis (or fibrosis). The extent of the fibrous change, of course, depends on the duration of the disease.

In the acute form the liver, to the naked eye, appears to be but very slightly altered. In the sub-acute form the organ is visibly fibrous, and is rather tough to the touch. In the chronic form, liver is markedly fibrous, and quite tough in consistency.

Diagnosis.—The chain of evidence strongly points to the so-called "disease" being a more or less chronic poisoning due to the ingestion of a local weed or plant with toxic properties. Supporting evidence for this is as follows:—

(*a*) The local occurrence of the disease (on certain stations and in certain districts only).

(*b*) The appearance of the disease regularly each year, and at the same time each year.

(*c*) The non-infection of contacts.

(*d*) The failure of attempts to produce the disease in healthy horses by inoculation with blood and serous effusions from animals in the acute stage of the disease.

Economic Importance.—Since the year 1888, when the disease was first reported from the Kimberleys of Western Australia, "walkabout" has been responsible for yearly losses running into many thousands of pounds. In certain localities the cattle stations lost up to 25 per cent. of their horses each wet season. Occasionally, the losses are considerably heavier. During the 1926 season, one small pastoralist lost 66 out of a total of 82 head of horses. Station owners and managers have come to regard the losses as inevitable, and accept the yearly mortality as a matter of course.

The constant losses have been a serious drawback to the cattle industry in the North. Many stations have been forced to abandon the use of horses almost entirely, and to fall back on mules for operating with stock. Mules seem to be less subject to, if not entirely free from, the ravages of the disease, but they are far less suitable than horses for stock work.

3. Scope and Results of Investigations.

In 1927, the Council for Scientific and Industrial Research decided to carry out investigations with a view to determining the cause of the disease, and to devising methods for its control. The Western Australian Government agreed to contribute towards the cost of the work. A programme of experiments accordingly was drawn up by Professor H. A. Woodruff in conference with Professor Ewart and the writer. The scheme included—

(i) A close study of symptoms in live animals affected.

(ii) The making of post-mortem examinations on horses that had died of the disease.

(iii) A botanical survey.

(iv) Feeding experiments on healthy horses with plants suspected of being responsible.

(v) Inoculation experiments effected with blood and serous exudates from horses affected with the disease.

The University of Melbourne agreed to make the services of Professor A. J. Ewart available for a period of four months, and he and the writer left for the Kimberley district, and arrived there in April, 1927. Although by this time the wet season was over and the period when "walkabout" is most prevalent had passed, the investigators were able to observe during life, and after death make post-mortem examinations of several horses which had developed the disease naturally on surrounding stations. A detailed description of each was recorded. A number of inoculation experiments were carried out with negative results.

Fitzroy Crossing, 210 miles inland from Derby, was made the centre for experimental work. The next step was a botanical survey of the locality by Professor Ewart. The list of plants was then compared with that of the Gilbert River area, in Queensland (compiled by Mr. C. T. White), where "walkabout" disease also occurs. It was obvious that, if the cause were plant poisoning, then the plant responsible must occur in both localities. By a process of comparison, a large number of plants could be rejected with a fair degree of certainty (i.e., plants occurring in the Gilbert River district and not in Fitzroy Crossing, and vice versa).

This reduced the possibilities down to a relatively small number. Of these possibilities, there was the further requirement that the plant causing the damage must be one which is fairly plentiful, and one which is eaten voluntarily by horses. This further reduced the number of likely plants.

From these lists it thus appeared that, if the disease were due to plant poisoning, the most promising plants to investigate would be species of *Crotalaria, Indigofera, Atalaya,* and *Tephrosia,* although nearly 50 varieties of plants were regarded as possible causes.

Feeding experiments were commenced on the 10th May, 1927. Careful tests with four species of *Crotalaria* and with two species of *Indigofera* extended over a period of seven weeks. The results in each instance were negative.

Atalaya (commonly called "Whitewood") was then tried. A black mare was placed on a daily dose of 4 lb. of leaves of the plant (in addition to ordinary diet). Ten days later, the mare developed preliminary signs of the disease. Within three weeks the animal developed typical "walkabout," and died. A post-mortem examination was made, and the findings were identical with those in horses which had died naturally of the disease. The investigators now believed that they were on a valuable clue, and therefore ceased experiments with all other plants. It was now necessary to confirm this positive result by further producing the disease in a number of healthy horses.

Five perfectly healthy horses were immediately placed on varying doses of *Atalaya* leaves. On the 4th October, after eleven weeks feeding on "Whitewood" (*Atalaya*), one animal developed the disease and died. On the 29th October, a further animal developed the disease and died. On the 1st November, the next horse died. On the 2nd November and the 3rd November, 1927, the two remaining horses died of the disease.

Throughout these feeding experiments four healthy animals were held as controls. These animals were grazed on the same pasture as the experimental horses, but they received no *Atalaya*. The four "controls" remained healthy throughout.

Sections of internal organs from each animal dead of the disease were sent in preservative to Mr. W. H. Bennetts, Veterinary Pathologist, Perth, and to Professor Woodruff, Melbourne, for microscopical examination. Reports from these pathologists indicate that in all experimental cases (as in cases of naturally acquired disease) the liver is the chief and constant seat of pathological change. The lesion is essentially that of fibrosis (or cirrhosis) in each instance.

Atalaya is a plant common to the tropical North. It grows to a height of 25 feet. Horses readily eat the leaves when grass is scarce and when better food is not available. At the time of writing (January, 1928) the four control animals have shown no sign of developing the disease.

The results of the field investigations and pathological findings all, therefore, point to the conclusion that Kimberley horse disease (or "walkabout") is a condition of more or less chronic plant poisoning brought about by continued ingestion of *Atalaya hemiglauca* (and possibly other species of *Atalaya*).

The toxic principle must be very slow in its action, as it takes weeks, or even months, to produce fatal effects, even when taken daily in fairly large quantities. It is likely that, when eaten in small quantities, and at irregular intervals, it may, in some cases, take even years to produce the disease. The fact that horses will voluntarily eat the plant without showing any immediate effects probably explains why *Atalaya* has never been in any way associated with "walkabout" by the layman. The same fact also explains why so many people claimed *Atalaya* as a "good fodder plant."

A detailed report on the disease, the methods of combating it, and on the work of the investigation is now being prepared, and will be published shortly by the Council.

Irrigation and the Control of Soil Water.

By E. S. West, M.Sc., Officer in Charge, Commonwealth Research Station, Murrumbidgee Irrigation Areas.

The following is a slightly abridged account of an address recently given by Mr. West to a meeting of settlers in the Murrumbidgee irrigation areas. Many who heard the address have requested that it be published.—Ed.

1. General.
2. Soil Moisture Relationships.
3. What Happens when Land is Irrigated.
4. Depth to Wet Soil.
5. Amounts of Water to Apply.
6. Methods of Irrigation.

1. General.

Irrigation is a highly specialized and intensive form of farming, and as such requires great skill and is beset with many difficulties. Of the problems confronting the irrigationist, undoubtedly the most important is the use of water, for although it is perhaps little realized, improper use of water may, and often does, lead to consequences more serious than gluts or disease. Although gluts may at times destroy the economic value of the products of the land, and disease may destroy the products themselves, improper irrigation will not only destroy the products, but it will also permanently destroy the land—as far as its agricultural value is concerned. This may seem a very gloomy outlook but for the consideration that with proper methods the greatest cultural difficulties usually associated with irrigation are overcome, the bug-bear—salt—is practically unknown, and as trees will develop deep and normal rooting systems, the tragedy of stocks dying out on reaching maturity is non-existent. In other words, irrigation will be permanent, and because the menace of drought is removed, less hazardous than dry farming.

2. Soil Moisture Relationships.

In order to understand irrigation properly, an elementary knowledge of the relationships existing between the soil and the soil water is required, and so certain of the so-called soil moisture constants will be explained.

The Hygroscopic Moisture.—Any naturally occurring dry soil—although it may be dust dry—contains some moisture known as the hygroscopic moisture, which can be driven off by heating the soil to the boiling point of water. The hygroscopic water cannot move through the soil from one soil grain to another by capillarity, but is very firmly

TABLE 1.—TYPICAL WATER CO-EFFICIENTS FOR VARIOUS SOILS.

Soil.	Hygroscopic Co-efficient.	Wilting Co-efficient.	Field Moisture Capacity.
	per cent.	per cent.	per cent.
Fine sand	2·1	3·1	8·0
Sandy loam	7·3	10·6	19·6
Loam	8·8	12·9	23·8
Clay loam	12·0	17·2	32·4
Clay	14·2	20·7	38·2

held. The maximum amount of hygroscopic water that a soil can hold (without becoming damp) is called the "hygroscopic co-efficient." Table 1 shows the extent to which the hygroscopic co-efficient varies

with the texture of the soil. Thus a clay soil, although dust dry, may actually contain as much moisture as a sand carrying as much water as it can retain. The finer the texture of the soil, or the more colloidal material it holds, the greater the hygroscopic co-efficient, and for this reason the latter has been used as a measure of the colloid content of a soil.

Capillary Water.—The capillary water is that water in excess of the hygroscopic water that a properly drained soil retains, after the excess has percolated away. The capillary water can move by capillarity from one part of the soil to another. The maximum amount of capillary water that a soil can hold is the "maximum water holding capacity" of the soil. This is rather a vague and indefinite quantity and difficult to measure.

Free or Gravity Water.—Water in excess of the capillary water will percolate and drain out of a properly drained soil and is known as the free or gravity water.

Field Moisture Capacity.—This is a field, rather than a laboratory term, and to all intents and purposes is the same as the maximum water-holding capacity. It is the maximum amount of water a soil can retain under field conditions after an irrigation, provided no hard pan or impervious layer is present. It is readily determined by determining the water present in a soil after an irrigation, before it has had time to dry out at all, and when sufficient time has elapsed for all the gravity water to percolate into the deeper layer. This is a very important quantity which greatly concerns the irrigationist and should be thoroughly understood. The great variation in the amount of water retained by different types of soil is shown in Table 1.

Wilting Co-efficient.—Growing plants withdraw moisture from the soil and transpire it through their leaves. In this way the soil is dried out. Provided no further water is added, as the soil becomes dry, the plants have greater difficulty in abstracting water and they wilt. The moisture content at which plants permanently wilt so that they will not regain turgidity (i.e., become fresh) is called the "wilting co-efficient." Even in very moist soil, plants will sometimes wilt before the wilting co-efficient is reached, if the weather suddenly becomes hot and dry, because the roots fail to adjust themselves to the sudden extra demands for moisture made by the leaves. This wilting is only temporary and the plants regain their turgidity in the evening. Plants can grow vigorously so long as the moisture content of the soil is above the wilting co-efficient. This then is the lower limit of the moisture content of the soil necessary for vigorous growth.

3. What Happens when Land is Irrigated.

When water is applied to land, the surface soil becomes saturated, with the result that the free water percolates down and wets successive layers, bringing the soil so wetted up to its field moisture capacity. When as much soil has been brought to its field moisture capacity as is possible by the amount of water added, very little further movement takes place. Actually, water will move by capillarity in any direction from moist soil to dryer soil, but once the moisture content is reduced to the field moisture capacity, capillary movement of water in the soil is very slow; in fact, for practical purposes negligible. This phenomenon

is of such importance that it should be thoroughly understood. Suppose, for example, we have a bulk of 1,000 lb. of soil at a moisture content of 10 per cent., i.e., containing 100 lb. of water. Suppose further that the field moisture capacity of the soil is 20 per cent. In order to bring the total volume of the soil up to field moisture capacity, an additional 100 lb. of water would have to be added. If only 50 lb. of additional water were added, only half of the soil would be brought up to the field moisture capacity and the other half would remain at 10 per cent. There would be a fairly sharp line of demarcation between the soil at 20 per cent. (maximum field capacity) and that at 10 per cent. (original moisture content). It is thus seen that a properly drained soil can be wetted only to its field moisture capacity. and neither to a higher nor lower moisture content. If insufficient water is added to bring the soil to its field moisture capacity, only part of the soil will be wetted; and if more water is added than is necessary to bring a soil up to its field moisture capacity, the excess will drain away provided it meets with no impervious layer.

If the excess water is held up by an impervious layer it is of no value to the plant, and is, in fact, detrimental as it excludes air and thus leads to the death of any plant roots present. The range of soil moisture content suitable for plant growth is thus from the wilting co-efficient to the field moisture capacity. The range for maximum growth is very large and lies somewhere within the limits just mentioned. Under practical conditions, the irrigationist will therefore obtain the maximum growth in his plants if he at all times keeps the whole of their rooting zone within these limits of moisture.

If the whole of the soil is just above the wilting co-efficient, good growth (quite possibly maximum growth) will take place. If, on the other hand, the whole of the rooting zone is just below the wilting co-efficient, the plant will wilt and growth practically cease, even though there may be very moist soil just below the rooting zone. If half the root zone is above the wilting co-efficient and half below, the plant will probably not show signs of lack of water but maximum growth will not take place. Hence the problem of obtaining maximum growth is not one of keeping the soil very moist, but in keeping the whole of the soil at all times above the wilting co-efficient. It is a common observation that young orchards that receive most water, grow the fastest. This is because by such methods of irrigation, no part of the soil is ever below the wilting co-efficient for long. These same orchards usually die out later on, owing to over-irrigation. By the use of correct methods the good growth can be obtained without such a danger.

It is necessary, of course, to apply water before the soil is actually reduced to the wilting co-efficient as irrigation has to fit into predetermined rotations, and if water is withheld too long the soil may dry out too much. Just when land will require water again after an irrigation must be learnt by experience.

4. Depth to Wet Soil.

Water should be applied to the soil so as to wet the whole of the root zone (or that part of the soil in which root growth is desired) to the field moisture capacity. The depth of this zone will vary with the soil. Three feet for a heavy soil, five feet for soils of moderate permeability and greater depths for light sandy soils may be sufficient for root development. The soil may be moderately permeable to a

depth of, say, four feet, after which percolation of the soil water is much slower. In such cases it would be better to rely on this four feet of soil for root penetration than to risk temporary waterlogging of the soil immediately above the less permeable soil. Young trees have not such extensive root systems as mature trees, and nothing is to be gained by wetting the whole of the soil. Two furrows—one on either side of the trees—are usually all that are necessary for young trees, and the soil should be wet only to say twelve inches below the root zone. It is, of course, necessary to wet the soil as far below and around the established root zone as to permit proper root development.

5. Amounts of Water to Apply.

If the actual percentage of water present at every depth, down to the full depth of the root zone could be determined, and the percentage at field moisture capacity together with the volume weight of the soil were known, it would be possible to calculate exactly the amount of water to apply. As none of these quantities can be determined by the practical farmer, he has to determine the size of his irrigation by observation and experience.

An approximate rule to start with is as follows. For every foot of soil that is almost dry, apply two inches, and for every foot that is half way to field moisture capacity, apply one inch. This necessitates sampling the soil by means of a soil auger or some other such device and this should always be done in one or two places before an irrigation. As soils vary so greatly in their moisture relationships, the above rules for determining the size of irrigations are only roughly approximate. In all probability, the farmer will at first apply too much water or too little.

To check this, samples should be taken to at least six feet a few days after irrigating, i.e., as soon as it would be possible to cultivate the land. If the soil has not been wetted to the full depth of the root zone, insufficient water has been applied. If on the other hand the soil is wet much below the root zone, too much water has been applied, and subsequent irrigations should be modified accordingly. Thus farmers should make borings both before and after irrigations, and carefully note the soil moisture conditions until they become sufficiently skilled to gauge the size of the irrigation accurately. Even when the amount of water to apply can be gauged, it is necessary to make borings before watering, as this is the only way to determine the size of the watering necessary.

Formation of a Water Table.—If when water is percolating down into a soil, a more or less impervious stratum is encountered, its downward movement will be prevented and free water will result. This constitutes the water-table. The depth of the latter can readily be measured by excavating a hole and noting the height to which water will collect in it.

As mentioned before, owing to the exclusion of air, roots will not penetrate saturated soil, and any roots present will die if the soil remains saturated for very long. The water-table, therefore, is a very effective barrier to further root penetration.

There is another very serious risk of a high water-table, and that is the rise of soluble salts and their accumulation at the surface. It has been mentioned that capillary movement of soil water from one

part of the soil to another is practically negligible so long as the water content of the soil is below the field moisture capacity. When the soil is saturated, however, as is the case at the water-table, capillary movement to the dryer soil at the surface is quite rapid, and the water thus moving carries with it salts in solution which are deposited near the surface when the water evaporates. Besides killing the plants, this may permanently ruin the soil, and is, in fact, the greatest danger attending irrigation. If no more water is applied to the soil than is necessary to wet it to its field moisture capacity, there will be very little capillary rise to the surface and no accumulation of salt; further, there will be no excess of water to join the water-table. Any water, however, added in excess of the amount required to bring the root zone to the field moisture capacity will be placed out of the reach of the roots, and is added to the dangerous water, which might in time cause the water-table to rise. Thus suppose the water-table is fifty feet deep and the roots develop in five feet of soil, if the soil is wetted to ten feet the first five feet will be dried out by the roots, but none of the water from five to ten feet will be available to the plant, and will remain in the soil. Any further water added at a later date below five feet will percolate still lower as the soil from five to ten feet is already at the field moisture capacity. Every time water is added in excess of the amount necessary to bring the root zone to the field moisture capacity, the wet zone below will be deepened until the water-table is finally reached. Further additions will then gradually raise the water-table. The importance of adding only sufficient water to bring the whole of the root zone to the maximum field capacity is therefore evident.

Cases Where the Water-table is Already High.—Cases where a high water-table already exists present particular difficulties. During the summer, it may be necessary to irrigate with the water-table within say four feet of the surface. It is quite possible, for example, for the roots to dry out the soil to the wilting co-efficient to a depth of eighteen inches although free water exists at four feet. In such a case, if water is withheld, the trees will undoubtedly suffer. On the other hand, unless great care is exercised in irrigation, water will be added in excess and the water-table will probably be raised nearly to the surface. It is possible, however, to irrigate the soil under such circumstances without raising the water-table at all, but at the same time wetting the whole of the dry soil. To do this, it may be necessary to apply not more than one or two inches of water, which is generally rather difficult. If no excess water is added, however, the water-table will not be raised during an irrigation, and the trees by drawing water from the soil will gradually lower it, and thus the menace of the high water-table will in time be removed by the trees themselves, provided that the fertility of the soil has not already been impaired by the rise of salt.

Owing to their small amount of transpiring surface the trees of a young orchard with a high water-table will not be able to lower the water-table effectively. In such cases, it is advisable to plant between the trees a deep rooting crop with a large transpiring surface (such as Bokhara clover) to help to reduce the water-table. No more water should be applied than is necessary to germinate the crop and probably the usual rainfall will be sufficient to do this. When the crop is established, no water should be applied to it though water

will be supplied to the trees to keep the adjacent soil above the wilting co-efficient. The roots of the clover will then follow the water-table down and lower it sufficiently to remove the menace.

Settlers finding that they have a high water-table should give the matter very serious attention and remove the danger as explained, before serious consequences occur.

By the construction of a few test wells (1) over the orchard, a high water-table may always be detected, and if present, any fluctuations in it may be observed. It should be clearly understood, however, that by correct irrigation a water-table is not formed.

Summing up, a few permanent test-wells should be distributed over the orchard, as indicators of a possible danger. Borings should be made at least six feet deep both before and after irrigations. From the observations of the first set of borings, the amount of irrigation water to apply should be determined. The second set of borings is a check on the irrigation. If it is found that the soil has not been wetted to the full depth of the desirable root zone, insufficient water has been applied. If, however, the soil has been made wet below the depth of the desirable root zone, or if a water-table is present and has risen as the result of the irrigation, too much water has been applied, and the irrigation practice must be modified accordingly.

6. Methods of Irrigation.

Methods to be adopted in applying water to the soil vary according to the type of soil, grades, amounts of water applied, and several other factors. It is not intended here to deal at length with all the numerous methods, but to deal merely with certain points relating especially to the problem of applying the desired amount of irrigation water, and applicable to Australian irrigation areas.

As far as most irrigated orchards in Australia are concerned, water is usually most conveniently applied in furrows.

Where the soil is heavy the greatest difficulty in this method is to apply a sufficient quantity of water to wet the soil to the full depth of the desired root zone, say four feet. Although it is more difficult to make heavy soils absorb water than is the case with the lighter soils, the field moisture capacity of heavy soils is much greater than of light soils and they therefore require more water. In such soils, water should be applied with a small head and for a long time. In very heavy soils, the basin method of irrigation may be employed to effect proper penetration.

If heavy soils are insufficiently irrigated and only the surface foot is wetted, trees will be shallow rooted, as roots will not penetrate dry soil. Shallow rooting of trees on heavy soils is very familiar, and is usually ascribed to the difficulty of the roots in penetrating the clay. Roots will, however, penetrate and disrupt rocks so long as moisture is present, but they will not penetrate a dry matrix be it rock, heavy clay, or river sand. Normally, if the soil is in a correct moisture condition, roots will penetrate to the desired depth.

Sandy soils have only a very small field moisture capacity, but, as in such soils plants require a greater feeding zone, it is desirable to wet them deeper than heavy soils. Owing to the ease with which light soils absorb moisture, there is a great tendency to over-irrigate them, which is the chief difficulty attending their management. In

(1) Test wells can be constructed by sinking a hole 5 to 6 feet by means of a soil auger, introducing therein a length of perforated down-pipe.

applying water to light soils the criterion often adopted as to when enough water has been applied, is the time the water takes to reach the end of the furrow. The more easily water penetrates the soil, the longer it takes for the stream to reach the end of the furrow, and hence, under this system the longer the water is in the furrow, whilst if the water is properly applied, the more permeable the soil the shorter the time of irrigation. It is not uncommon for eight or twelve inches of water to be applied to a light soil in the endeavour to "get the water over the land" when no more than three inches is required. Under these circumstances, the excess five to nine inches percolates out of reach of the roots and is not only wasted but causes the water-table to rise to the surface with the resultant accumulation of salt.

The amount of water applied to the land should depend solely on the amount required to bring the rooting zone to field moisture capacity. The question arises how can this be done on light soils without over irrigating. The problem certainly is difficult, but can be overcome by the use of shorter furrows, or greater heads of water in the furrow or both. It may be impracticable to shorten the length of furrows unduly, but by using deep furrows almost any head can be employed, it being only necessary to reduce the number of furrows irrigated at the time.

The number of furrows to be used depends largely on the texture of the soil and the size of the irrigation. In heavy soils, the lateral seepage is more pronounced and the resultant curves showing the water penetration are rather compressed, while in sandier soils the effect of gravity predominates and the curves are more drawn out, i.e., the vertical axis is relatively greater than the horizontal axis. If the furrows are correctly spaced, the curves of adjacent furrows should overlap after enough water has been applied to penetrate to the required depth and after the movement of the water has practically ceased.

It should be noted that the surface of the soil is not necessarily wetted. A common fallacy is to consider the land properly irrigated when water from adjacent furrows has seeped sufficiently to meet at the surface. Roots do not grow in the surface few inches, and there is no need to wet the surface soil more than necessary. The less the depth it is desired for the water to penetrate, the closer together the furrows should be placed; also, considering the influence of texture on the penetration of water, the lighter the soil the more frequent the furrows, as the less pronounced is the lateral seepage. Thus, if it is found on examining a sandy loam soil that only two feet of the soil requires addition of water, as below this depth the soil is almost at maximum field capacity, it may be necessary to use six or even eight furrows to the bay, instead of the usual four. If only three inches were required to raise the surface two feet to the maximum field capacity, it would be necessary to irrigate very rapidly, using large heads, in order to cover the ground before too much soaked in near the head ditch.

It is extremely difficult to apply water so that the same amount soaks into the soil the whole length of the furrow. Generally speaking, far more soaks in near the head ditch than lower down, and often excessive quantities also soak in at the end of the furrows. Shorter furrows overcome this difficulty to a certain extent, while a suggestion that should be tried in many cases is to use an initial big head and adjust the flow after the water has reached the end of the furrow. Where a spray system of irrigation is used, the problem of applying just the correct amount of water, and applying it uniformly, is very much simplified.

PLATE 1.

THE CATTLE TICK PEST IN AUSTRALIA.

FIG. 1.—A heavily tick-infested animal used in the experiment by the Cattle Tick Dip Committee.

FIG. 2.—Map showing the tick-infested areas of Australia.

C.432.

PLATE 2.

THE CATTLE TICK PEST IN AUSTRALIA.

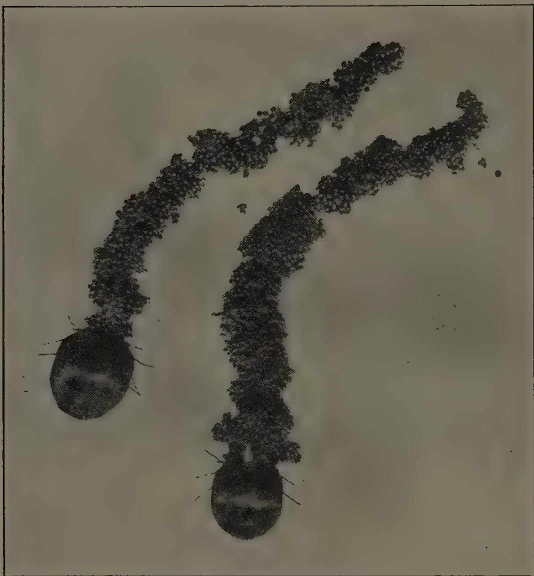

FIG. 1.—Ticks laying eggs.

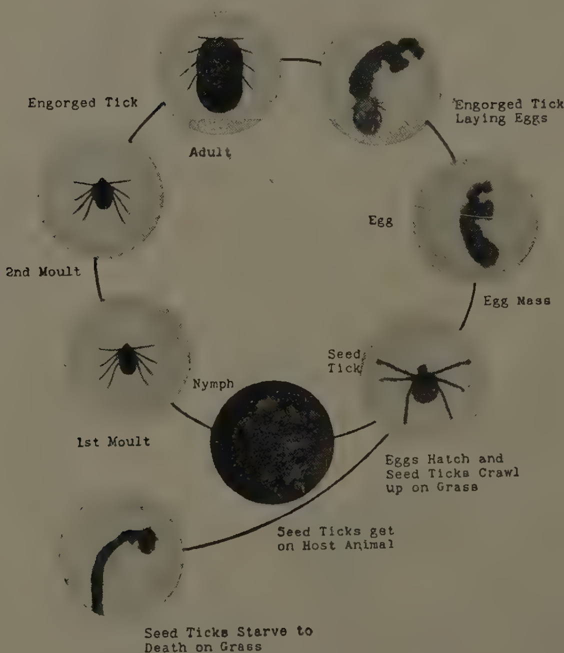

FIG. 2.—Life cycle of the Cattle Tick.

PLATE 3.

WALKABOUT, OR KIMBERLEY HORSE DISEASE.

FIG. 1.—First experimental animal in which "Walkabout" was produced by feeding on *Atalaya*. Note the typical attitude of pushing stupidly against the fence.

FIG. 2.—In the last stages. The animal frequently assumes abnormal attitudes.

PLATE 4.

WALKABOUT, OR KIMBERLEY HORSE DISEASE.

FIG. 1.

A further experimental horse in the last stages, and showing the typical symptom of desiring to reach a habitation. Here the animal is entering a shed in which natives sleep.

FIG. 2.

The plant responsible. A tree of *Atalaya hemiglauca.*

PLATE 5.

THE PRODUCTION OF BRIGHT FLUE-CURED TOBACCO IN AMERICA.

A flue-curing barn made of logs. This type of barn is general throughout North and South Carolina.

(Photo. by courtesy of the U.S. Department of Agriculture.)

PLATE 6.

THE PRODUCTION OF BRIGHT FLUE-CURED TOBACCO IN AMERICA.

An American Tobacco Crop ready for harvest.

(Photo. by courtesy of the U.S. Department of Agriculture.)

NOTES.

Agricultural Economics: Report to the Empire Marketing Board.

The Empire Marketing Board, having received applications for grants for the purpose of carrying out research work into certain aspects of agricultural economics, and having made certain grants for research work into marketing problems, summoned an informal conference on 11th July, 1927, to discuss the present position of research on agricultural economics in the Empire.

A result of this conference was the appointment of a committee for the preparation of a report, which might serve as a basis for discussion at the Imperial Agricultural Research Conference held in October, 1927. In due course the Committee furnished a report, which has recently been printed and issued by the Empire Marketing Board. The Committee secured the services of Mr. J. P. Maxton, of the Agricultural Economics Institute, Oxford, for the drafting of the report, which is drawn up in sections.

Section I. is introductory. The Committee welcomes the inclusion of the subject of agricultural economics among the topics to be discussed at the Imperial Agricultural Research Conference, the general feeling being that the study of agricultural economics in the Empire is still relatively undeveloped, and that this subject should be recognized as an essential part of agricultural research.

Section II. is descriptive. It gives a short account of the agricultural economic laboratories established in various parts of the Empire, and the types of inquiry by which farmers' conditions are reviewed. Up till recently there have been three main types of such inquiry:—

(i) By individual observers.

(ii) By Government Commissions and Committees of inquiry.

(iii) By research workers in the field of applied natural science.

Though all these methods are useful there are objections to each, and it is clear that economic research must have a technique of its own, and its observations must be continuous. That this need is becoming realized, is shown by the rapid growth of Agricultural Economic Research Stations during the last few years.

Section III. deals with statistics. The method of agricultural economics is to combine accurate intensive observations with analysis and interpretation of statistics. The Committee suggests that joint discussion between statisticians and economists is desirable, and it attaches particular importance to the projected World Agricultural Census of 1930.

Section IV. emphasizes the importance of agricultural geography as a background in the study of agricultural economics. The Committee recommends that the preparation of agricultural atlases should receive special attention from the Governments of the Empire.

Section V. discusses farm management. The two principal methods of research are:—

(i) *Cost Accounting.*—A system of cost accounting has been developed by the Agricultural Economics Research Institute at Oxford, and has been somewhat generally adopted in England and Wales. According to this system, the

farmer makes certain records at specified intervals of time throughout the year. These records are collected from the farm to the Research Department, where the office work is done.

(ii) *The Survey Method,* which is extensively used in the United States of America, also to a certain extent in parts of the British Empire. An investigator visits as many farms in an area to be surveyed as possible. He collects data from the farmer as to the condition of his farm. The data from all the farms are totalled, and from them the statistics are deducted. The Committee emphasizes the value of both systems of investigation.

Section VI. refers to marketing. Special interest is attached to the study of prices, as the farmer immediately depends on the prices he receives. The study of prices, however, requires to be supplemented by further fundamental research into the analysis of supply, analysis of demand, forecasting, &c.

Section VII. deals with co-operation, the main aims of co-operative marketing being:—

(i) The abolition of waste through a multiplicity of agencies.

(ii) The elimination of excess margins of profit by middlemen.

(iii) Grading and standardization.

(iv) Orderly marketing for the purpose of levelling fluctuations of prices.

Section VIII. is concerned with such problems as transport, credit, monetary policy, taxation, insurance, rural sociology and land economics. The Committee attaches importance to the question of securing publicity for the results of research.

Section IX. discusses the application of the results of agricultural economic research, to the improvement of farming conditions. One of the aims of agricultural economic research is that of building up a knowledge of the wider economic forces controlling world production and world markets, as a guide to the more fundamental policies underlying individual and national systems of farming.

Looking to the future, agricultural economics aim at advancing, like medical science, from diagnosis to healing and from the healing of sickness to the promotion of health. But the possibilities of the subject in the future depend upon the years of field work, and on the patient analysis of local conditions. The local researches must be built up together, in order to develop the full value of agricultural economics in promoting the prosperity of Empire agriculture.

Entomological Problems—Assistance of the Imperial Bureau of Entomology.

(*a*) *The Underground Grass-grub in Tasmania.*—In a previous issue of this Journal (Vol. 1, No. 1, page 18), a reference was made to the serious damage done to Tasmanian pastures by underground grass grubs. Investigations recently carried out by one of the Council's officers—Mr. G. F. Hill—seem to indicate that whilst artificial methods of control such as poisoning are economically possible on certain classes of grazing land, they cannot be profitably employed on

the hilly and partly cleared areas of the State. It was hoped that effective natural enemies of the grubs might be found in South Australia or Victoria where allied species occur in less numbers, and where they do not cause so much damage as in Tasmania. The results of this research, however, have not been encouraging to date. Nevertheless, inquiries are now being made in Queensland where at least three species of *Oncopera* are known to exist. One of the species causing the most damage in Tasmania has been identified as *Oncopera intricata* Wlk. The Director of the Imperial Bureau of Entomology—Dr. G. A. K. Marshall—has accordingly been asked to advise as to whether some investigations could be made by the Bureau on the ichneumon fly parasite of *Hepialus humuli* L. and on the parasites, if any, of other species of *Hepialidæ* with a view to securing a consignment for employment against *O. intricata* in Tasmania.

(*b*) *Lucerne Flea.*—At the present time, the lucerne "flea" (*Smynthurus viridis*) is a serious pest in certain localities in South Australia where it interferes considerably in the growing of certain crops such as lucerne, clover and even cereals. The insect also occurs in Western Australia, and it is extending into Victoria from South Australia. Most of the entomological studies that have been carried out on the insect in Australia have been made by various workers in South Australia. Some of the most recent work has been carried out at the University of Adelaide by Mr. F. G. Holdaway, late demonstrator in Zoology at that University, but now located in the United States of America as one of the Council's research trainees. It is probable that on Mr. Holdaway's return to Australia a further investigation of the pest will be made. In the meantime, the Imperial Bureau of Entomology has been asked whether it could make a preliminary study of the insect and of its natural enemies in Great Britain. In Europe the "flea" is relatively unimportant when considered from the point of view of a pest, and it is possible that an investigation of the reason for this state of affairs will throw much light on the methods most likely to lead to the control of the insect in Australia.

The Department of Scientific and Industrial Research, New Zealand.

The New Zealand Department of Scientific and Industrial Research, which is the corresponding body to the Council for Scientific and Industrial Research in Australia, was constituted by an Act passed in the middle of the year 1926. Like its counterpart in Australia, the New Zealand body was formed after the local Government had received a report on the matter from Sir Frank Heath, late Secretary of the British Department of Scientific and Industrial Research.

The first annual report of the Department has just recently been issued. That part of it dealing with work already accomplished is naturally confined to those scientific services, such as the Dominion Laboratory, the Dominion Observatory, &c., which had previously existed, but which in New Zealand have been brought under the control of the Department in greater numbers than has been considered necessary with the corresponding institutions in Australia.

Much new work, however, has been commenced. In particular, arrangements are in train for the formation of a Technological Bureau of Information to be attached to the Dominion Laboratory. A scheme

of dairy research has been agreed upon and the New Zealand Dairy Produce Board has signified its willingness to contribute half the cost up to £3,000 per annum. The Department is also urging the necessity for further research in connexion with mammitis and abortion diseases in cattle. A special committee has been set up to arrange for the establishment of a research station in conjunction with the Agricultural College at Palmerston North to deal with the diseases of plants and seeds. In co-operation with the Empire Marketing Board, the Department has initiated a fundamental research into the nutrient value of New Zealand grasses and fodder plants and two workers have already been sent to the Rowett Institute, Scotland, to ascertain the precise methods of research followed at that place. As regards liquid fuels, the Department is adopting a very similar attitude to that of the Australian body and is in the main merely watching the developments taking place in other countries. In the field of cool storage a report is being obtained from Dr. F. Kidd, who previously reported on Australian conditions and then proceeded to New Zealand. The Department is also very closely connected with standards and standardization matters in New Zealand. In addition, it either has already initiated or has under consideration researches in regard to a number of miscellaneous matters, such as forest products, fisheries, vitamins, building stones, wool, leather, &c. It has acted in co-operation with the Department of Industries and Commerce and already a partial survey of the problems concerning the secondary industries has been made. It has also made several grants to various scientific investigators, and has established a bureau of information and a central library for research workers.

An Insect Pest of the Eucalyptus Tree.

An interesting and recent example of the comparatively new method of controlling insect pests by means of other beneficial insects is afforded from South Africa. As is well known, eucalypt trees from Australia have been planted in that country on a large scale partly in order to ensure adequate supplies of timber for mining purposes. Recently, however, the eucalyptus snout beetle (*Gonipterus scutellatus*) has become a very serious pest. So serious is the trouble that the Entomological Division of the South African Department of Agriculture recently sent out one of its officers—Mr. F. G. Tooke—to Australia in order that he might search for parasites of the beetle. In Australia, the beetle certainly occurs and causes some slight damage to certain varieties of eucalypts and in particular to *Eucalyptus viminalis,* but it is kept in such control by other insect parasites that the total damage it causes is practically negligible. The eggs are laid on the young leaves about the middle of July and hatch in two or three weeks. The larvæ then feed steadily for five to eight weeks, after which they drop to the ground and pupate. In Australia, it is a common experience to see caterpillars and grubs on the leaves of eucalypt trees and to note some slight damage to the foliage of the latter, but it is extremely rarely that this damage leads to the death of the tree or even to any appreciable effect on its growth. In South Africa, however, such damage often leads to the death of the tree.

After a preliminary survey, Mr. Tooke established a field laboratory at Penola, near Mount Gambier, South Australia. As a result of his investigations there, he discovered that a minute wasp of the Mymaridæ family parasitizes the eggs of the snout beetle, and that so heavy is this parasitization in Australia that the beetle is effectively controlled. Mr. Tooke, who has now left Australia, sent several consignments of the wasp to South Africa where a clean stock (i.e., one free from hyper-parasites that would control the wasp) will be obtained prior to the liberation of the wasp on a large scale.

Haematuria in Cattle at Mount Gambier.

Mr. Campbell Dickinson, B.V.Sc., has recently furnished a progress report on his investigations on endemic redwater (haematuria) in cattle in the Mount Gambier district of South Australia. This disease is a constant menace to the dairying industry of the district for losses are heavy and continuous. So severe have the latter been, that in some cases farmers have been forced to give up dairying altogether.

Work was carried out throughout the three months of September, October and November of 1926. A rough survey has been made in order to determine the geographic distribution and the incidence of the disease in the affected area. The natures of the various soils have been noted and botanical surveys made on certain farms. In addition urine samples, bladder lesions, &c., have been examined at the Mount Gambier Hospital where laboratory accommodation was kindly provided by those in charge. Other samples are also being examined by Mr. Dickinson at the Pathological Laboratory of the Adelaide Hospital where the investigation is being carried out under the direction of Dr. Lionel Bull, the Director of the Laboratory.

The investigation has been greatly facilitated by the assistance rendered by Professor A. J. Perkins, Director of the South Australian Department of Agriculture in the shape of the services of two of his staff—Mr. E. S. Alcock and Mr. W. H. Wood. It is as yet too early to expect any definite results.

International Conference of Wheat Experts, Rome, 1927.

In April, 1927, an important conference of wheat experts was held in Rome at the instigation of the International Institute of Agriculture. Advantage was taken of the presence in Europe at the time, of one of the members of the Council—Professor R. D. Watt—in order to arrange for him to represent Australia. Professor Watt has recently furnished a short report on the deliberations of the Conference, a full account of which will be published by the Italian authorities later. The genetics and ecology section was attended by a distinguished group of plant breeders and important discussions took place on breeding for disease resistance and breeding for quality. The opinion was generally expressed that breeding for rust resistance was the most complex and difficult problem which the wheat breeder encountered. The proceedings of the Conference when published will be of considerable value to all interested in the scientific aspects of the production and marketing of wheat.

Poison Plants.

The Poison Plants Committee of the Council has commenced its investigations and has already obtained some results. It has decided that immediately it discovers any particular plant to be poisonous, it will inform all State Departments of Agriculture accordingly. Recently it has informed the Departments that the following Australian plants contain cyanogenetic glucoside:—*Acacia glaucescens* and *Acacia doratoxylon*. In other words, these plants contain material which may give rise to hydrocyanic (prussic) acid, and so are dangerous to stock.

Agricultural Research Government Assistance in South Australia.

The State Government of South Australia has recently passed an Act which will have important bearing on the agricultural research to be carried out in that State in the future. It is proposed to afford immediate financial assistance to the Waite Agricultural Research Institute of the University of Adelaide to the extent of £5,000 per annum. This amount will be increased by £1,000 per annum each year (£2,000 in the first year) until in 1936 it will reach the amount of £15,000 per annum. The grant is being made in order that the Waite Institute shall conduct researches in cereal breeding, plant genetics, plant nutrition, the improvement of pastures and pasture plants, agricultural chemistry, soil management and soil classification and various other matters. The Act also provides means whereby the Government may in the future secure scientifically trained agriculturists for service in the Government Departments. It empowers the Council of the University to nominate to the Minister of Agriculture not more than four persons a year who have taken a course in Agricultural Science at the University. The Government will be required to employ any person so nominated at a salary of not less than £300 per year in one of the Government Departments where agriculturists are required.

Cold Storage Investigations—Meat and Fish.

A considerable amount of attention has recently been given by the Council to the report on cold storage investigations furnished by Drs. F. Kidd and W. J. Young. As a result, it has been decided that, for the present, investigations on the preservation, transport, and storage of meat and fish, should be carried out separately from similar investigations on fruits. By kind permission of the authorities of the University of Melbourne arrangements have accordingly been made to have this work undertaken in the Biochemical Laboratory of the University and under the direction of the head of that Laboratory—Associate Professor Dr. W. J. Young. No very definite lines of investigation have yet been laid down but it is probable that some of the work will be of an applied nature and that some of it will be semi-fundamental. The investigations on fish will be helped by the survey of the industry now being made by the Fisheries Conference convened by the Development and Migration Commission. Dr. Young is a member of that Conference.

Any expenses that may be incurred in the course of the work will be met from the funds of the Council.

Recent Appointments.

The first Annual Report includes a list of the staff of the Council as it existed at that time. Since the issue of that Report the following staff appointments have been made.

Dr. Jean White-Haney has been appointed to the Head Office staff as a scientific assistant. This appointment was made to fill a vacancy that remained after the resignation of Mr. E. Mackinnon and the subsequent reorganization of the late Institute. Dr. White-Haney is a graduate of the University of Melbourne in botany, and for many years has been closely associated with the research work being undertaken in regard to the control of prickly pear, more particularly by poisoning.

Mr. Colin Barnard, B.Sc., is a graduate of the University of Sydney in botany. He has been appointed to the position of Botanical Assistant at the Commonwealth Research Station, Merbein, where he will assist in the viticultural investigations that are being undertaken at that place.

Visit to Australia of Sir Arnold Theiler and Dr. J. B. Orr.

During his recent visit to Europe, Sir George Pearce discussed with Lord Lovat, Under-Secretary of State for Dominion Affairs and Major Walter Elliot, Chairman of the Research Grants Committee of the Empire Marketing Board, various questions relating to the work of the Council and to co-operation in Empire research. The latter co-operation was also one of the most important matters discussed at the Imperial Agricultural Research Conference held in October, 1927. It is expected that as a result of those discussions important actions for the developments in research in Australia will be taken. In the meantime, arrangements have been made for the visit to Australia early in 1928 of Sir Arnold Theiler and Dr. J. B. Orr.

Sir Arnold Theiler, K.C.M.G., was for many years Director of Veterinary Research and Professor of Tropical Veterinary Medicine in South Africa where he established the well-known Veterinary Research Institute at Onderstepoort and carried out research on many problems, especially on certain deficiency diseases in stock. Similar diseases of a somewhat obscure nature occur in various parts of Australia both on the mainland and in Tasmania. In addition to informing himself generally on the whole question of veterinary problems and research in Australia with a view to closer Empire co-operation, Sir Arnold Theiler will advise the Council as to the immediate development of its plans for research in these problems.

Dr. J. B. Orr, D.S.O., M.C., M.A., M.D., D.Sc., is the Director of the Rowett Institute, Aberdeen, one of the principal institutions in the world for research on animal nutrition problems. When in Australia, he will consult with Professor Brailsford Robertson who is in charge of the local investigations on animal nutrition being undertaken by the Council, and he will also make himself personally conversant with the conditions and problems of nutrition confronting the Australian pastoral industry.

It is expected that both Sir Arnold Theiler and Dr. Orr will reach Australia per the R.M.S. *Orama* early in April next The former will remain for some six months but the duration of the latter's visit will be for about two months only.

Radio Research—Royal Commission on Wireless.

The report of the Royal Commission on Wireless, which has been inquiring into radio matters in Australia, has recently been issued. Dealing with scientific research the Commission after discussing the organizations now undertaking research in radio in Australia, recommends as follows:—

> "That a special appropriation sufficiently large to enable the present problems in radio to be thoroughly investigated should be made available to the Council for Scientific and Industrial Research."

The British Development Commission—Annual Report.

The British Development Commission was set up in the year 1909 for the purpose of making advances from a special fund created for (*a*) the development of agricultural education and research, (*b*) the development of the countryside, and (*c*) fishery investigations and development.

The 17th Annual Report of the Commission for the year ended 31st March, 1927, which was recently presented to the House of Commons gives, inter alia, an interesting account of agricultural research work which is at present being undertaken in the Research Institutes throughout Great Britain. The Commission is now working in close co-operation with the Empire Marketing Board with the result that augmented funds have been made available to the existing Research Institutes for investigations having an Imperial significance. The total sum recommended by the Commission alone, for the maintenance of the work of Agricultural Institutes and Stations in England and Wales in the academic year 1926-27, was about £140,000.

Some of the more interesting investigations in progress at the various Institutes are mentioned in the following paragraphs. Full reports are given from time to time in the various publications of the Institutes.

(*a*) *Rothamsted Experiment Station, Harpenden, Herts.*—The investigations at Rothamsted are concerned with information in regard to growth of crops and the relationships of the plant to the soil. Important results of value in the design of farming implements have recently been obtained by an analysis of field records and a study of the parts played by plasticity, cohesion and surface friction between the soil and the implement. The relation between seasonal variation and effectiveness of fertilizers is being obtained in the statistical department. Considerable advance has been made in the investigations on synthetic manures and it has now been found possible to make good manure from such substances as cocoanut fibre and hop string, binder twine, &c.

(*b*) *University of Aberdeen and North of Scotland College of Agriculture.*—Investigations on the soils of the north-east of Scotland are being undertaken. It is intended later to evolve a uniform scheme for classification and survey for the soils of the whole of Great Britain. Co-operation has been arranged with the Geological Survey for the production of maps more suitable for agricultural purposes than those

in use at present. An investigation is being undertaken to ascertain the amounts of chlorides, sulphates, and nitrogen brought to the soil from the atmosphere. Monthly analyses are being carried out on the rain water.

(*c*) *Research Institute of Plant Physiology—Imperial College of Science and Technology.*—The work of this Institute has for its object the study of the physiological processes of the plant which are responsible for crop production. For example, those on the physiological effect of mineral substances on the growth of barley have resulted in information on the effect of increasing quantities of nitrogen and phosphate on flower production, flower sterility and ripening of grain. The relationship between the degrees of sterility and quantity of phosphate has been clearly brought out. Electro-culture experiments have shown that with low phosphate manuring the effect of electrical discharge was to lower the percentage of sterility while higher phosphate manuring gave the opposite result. Physiological work on propagation has shown that the greatest success with cuttings can be obtained with stems not in active growth, and planted early in the year; and that etiolation of the base of the stem improves the rooting. By growing cucumber plants in air containing an enhanced content of carbon dioxide and with an appropriate temperature and illumination it has been found posible to increase the dry weight of the plant by 80 per cent. in eleven days.

(*d*) *Plant Breeding Institute, Cambridge.*—The work of the Institute was carried out along the same lines as in previous years, breeding experiments being continued with wheat, barley, oats and potatoes.

(*e*) *Welsh Plant Breeding Station—Aberystwyth.*—This station is chiefly concerned with problems bearing on herbage plants and the improvement of crops likely to be of the greatest assistance to farmers whose holdings occupy land of rather low average fertility and those situated in upland regions. The possibilities of breeding improved species as well as the putting down of land to grass and the management of temporary grass are the main problems. In regard to the introduction of suitable species the results obtained are of local interest only, but the results which it is hoped to obtain in regard to the management of grass land carrying stock, and to the persistency and aggressiveness of herbage plants, will be of value everywhere.

(*f*) *Scottish Plant Breeding Station, Corstorphine, Midlothian.*—Breeding work is being carried out on oats, potatoes, herbage plants and swedes. In the work on herbage plants, it has been ascertained that in perennial rye and other grasses, self sterility and partial self sterility are very common. It has also been indicated that less variability of type is likely to occur by breeding from individual plants from "wild" local populations than from cultivated strains. The wild populations have always produced progeny containing a higher proportion of desirable grazing types.

(*g*) *National Institute of Agricultural Botany, Cambridge.*—The work of the National Institute is divided into three branches (*i*) Crop improvement branch; (*ii*) Seed testing branch; (*iii*) Potato testing station. The work of the Institute continues along the same lines as formerly, new varieties being given three year field trials before judgment is pronounced on their value. The Potato Testing Station continues to examine varieties for synonymity, and it is also undertaking investigations on the methods of infection of virus disease.

(*h*) *Long Ashton Fruit Research Station, Bristol, University.*—Fruit culture, diseases of horticultural crops, and fruit preservation and products, are the main lines of investigation at this Station. In addition all questions relating to willow cultivation (for cricket bats, &c.), and the uses of osiers in rural industries are receiving attention. It has been found that willows allowed to grow two years before cutting show an increase of from 50 per cent. to 100 per cent. above the yields from one year's growth. With the assistance of the Linen Research Institute an investigation has been commenced on the extraction of fibre from willow bark. Results so far indicate that the fibre is of little value.

(*i*) *Chipping Campden Sub-station for Fruit and Vegetable Preservation.*—An examination of various methods of preservation and of various products of fruit and vegetables is in progress in an experimental factory. Experiments to determine the best processes for making jam and jellies and canning of peas are yielding interesting results.

(*j*) *Horticultural Research Station, East Malling.*—Special attention is being paid to the root stocks upon which fruit trees are grafted and a systematic physiological study is being made of the relation between stock and scion. East Malling is also growing and drying for chemical analysis and brewing trials, all the leading commercial varieties of hops.

(*k*) *Experiment and Research Station, Cheshunt, Herts.*—This Station is concerned with problems of glass-house cultivation. Important results have been obtained on the cultivation of cucumbers under hot-house conditions.

(*l*) *Animal Breeding Research Department, Edinburgh University.*—Owing to largely increased funds the activities of the Departments will be very much increased in the future. Valuable results have already been obtained on the quantitative estimation of kemp in the fleeces of sheep and in the determination of the fineness of wool and of the fleece. Investigations on fertility and fecundity of different breeds in relation to environment and in relation to age are not yet completed. The breeding of pigs, horses and cattle, is also under investigation.

(*m*) *Animal Nutrition Institute of Cambridge University.*—Fundamental investigations concerning the physiology of fattening, nutrition, reproduction, &c., of economic animals are being undertaken.

(*n*) *The Rowett Research Institute, Aberdeen University.*—The commodious laboratories of this Institute were opened in September, 1922. The main activity is the investigation of animal nutrition, particularly from the point of view of mineral metabolism. It has been found that pastures recognized as being of high feeding value and capable of supporting rapidly growing animals in good health, have invariably a high mineral content. The iodine content of pastures has also been extensively studied.

(*o*) *National Institute for Research in Dairying, Reading University.*—The Institute has been housed since 1923 on an estate of some 340 acres. Among the recent discoveries is that "oily" milk is caused by the passage of clean milk over a copper surface followed by its subsequent exposure to air and a low temperature.

(*p*) *Institute of Animal Pathology, Cambridge University.*—The work of this Institute is practically confined to the investigation of diseases of animals. A motor laboratory has been specially built and equipped in such a way that while being capable of considerable speed and mobility, it provides all the facilities required for a prolonged field investigation.

(*q*) *Research Institute—Animal Pathology Royal Veterinary College.*—Diseases of special interest to English animal breeders, e.g., braxy, parasitic gastritis, Johne's disease, tuberculosis and abortion in mares are being studied.

(*r*) *Institute for Research in Agricultural Economics, Oxford University.*—Considerable progress has been made with the study of the marketing of farm produce, and special attention has been given to the economics of the production of milk and of sugar beets.

(*s*) *Institute of Agricultural Engineering, Oxford University.*—Attention was given during the year to types of dryers suitable for various crops. A report on the use of windmills for power and for other farm purposes was issued.

The Destruction of the Hosts of the Liver Fluke.

By G. P. Darnell-Smith, D.Sc., F.I.C.

The water-snail, *Limnaea brazieri*, is generally regarded in Australia as the host of the liver fluke in its early stages, hence the destruction of these snails is an important means of preventing the occurrence of liver fluke in sheep.

Chandler, in America, has shown that copper sulphate is highly poisonous to water snails and that it may be used as a means of control. While *Limnaea brazieri* will live in pools, it seems to prefer slowly-moving streams, and is often to be found in the water trickling away from small springs. For the destruction of snails in running water, dipping into it at intervals a bag containing 4 or 5 lb. of copper sulphate tied on the end of a 5-ft. pole has been recommended. Copper sulphate, however, may not be the most suitable copper compound for the treatment of running water, since, on account of its ready solubility, it may be carried away by the running water and removed from its useful sphere of action.

An experiment carried out at the Sydney Botanic Gardens last year is of interest in connexion with the above. Two small aquaria were prepared. In each were placed a number of water weeds, and several specimens of Limnaea were introduced. A small bag containing copper sulphate was hung in one aquarium, and a small bag containing copper carbonate was hung in the other. Copper sulphate is extremely soluble in water, and the plants and the snails in the aquarium treated with it died very quickly. In the aquarium treated with copper carbonate, which is slowly soluble in water, the effect was not nearly so rapid, but nevertheless the carbonate caused, in a comparatively short time, the death of every plant and snail.

The suggestion is therefore made that, where the attempt is being made to free running water from snails, the experiment would be worth trying of anchoring a bag containing copper carbonate in a slowly-running stream and noting its effect. There would issue from around the bag water containing small quantities of copper, and the feed of this copper-containing water would be continuous. Thus, in running water, copper carbonate might prove more effectual than the easily soluble and rapidly washed away copper sulphate.

Copper carbonate is a substance of somewhat variable composition; its solubility in water depends upon the amount of carbon dioxide present. Hepburn[1] working with varying concentrations of copper sulphate and sodium carbonate in the preparation of copper carbonate, records that "At every concentration at which the precipitation was carried out it was found that a definite concentration of copper in solution was attained, after precipitation, dependent upon the concentration of carbon dioxide in the final solution. The relation between these two concentrations is represented by a smooth curve. The regularity of the results is striking, in view of the fact that the carbon dioxide contents of the precipitates obtained at each concentration were widely divergent, the value of x in the formula $2CuO, xCO_2$ varying from 1.052 to 0.623; in spite of this, these precipitates behave in the same way as regards their solubility in aqueous solutions of carbon dioxide, which suggests that they are of very similar chemical nature. Such would be the case if each precipitate consisted of hydrated cupric oxide with variable quantities of absorbed carbon dioxide."

(1) Hepburn, J. R. I., "The Chemical Nature of Precipitated Basic Cupric Carbonate," *Journal of the Chemical Society*, November, 1927.

H. J. GREEN
GOVERNMENT PRINTER,
MELBOURNE